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ACOUSTIC STUDIES IN INDIAN LANGUAGES

EDITED BY
B. B. RAJAPUROHIT

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CENTRAL INSTITUTE OF INDIAN LANGUAGES
MYSORE-570 006

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CURRENT INQUIRIES IN INDIAN LANGUAGES : WORKING PAPERS OF CIIL AND RLCs
1

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ACOUSTIC STUDIES IN INDIAN LANGUAGES

[Research Papers Prepared at the Summer Institute in Advanced Phonetics - 1984]

Edited by

B. B. RAJAPUROHIT

CENTRAL INSTITUTE OF INDIAN LANGUAGES
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FOREWORD

The Central Institute of Indian Languages was set up on the 17th July 1969 with a view to assisting and co-ordinating the development of Indian languages. The Institute was charged with the responsibility of serving as a nucleus to bring together all the research and literary output from the various linguistic streams to a common head and narrowing the gap between basic research and developmental research in the fields of language and linguistics in India.

The Institute and its six Regional Language Centres are thus engaged in research and teaching which lead to the publication of a wide-ranging variety of materials. Preparation of materials designed for teaching/learning at different levels and suited to specific needs is one of the major areas of interest of the Institute. Basic research relating to the acquisition of language and study of language in its manifold psycho-social relations constitute another broad range of interest. The publications include materials produced by the members of the staff of the Central Institute of Indian Languages and its Regional Language Centres and associated scholars from universities and institutions, both Indian and foreign.

Acoustic Studies in Indian Languages is the third volume in a series of phonetic studies publisahed by the Institute, *Acoustic Characteristics of Kannada* and *Papers in Phonetics and Phonology* being the earlier two. The Institute was publishing a series of **Phonetic Readers** in different Indian languages. Twentysix titles have already come out of the press and four are in the press. It was decided to discontinue the Phonetic Reader series, beyond 30. Meanwhile the Institute is developing pure and applied research in phonetics and the results of this research would be presented in monographs and the collected papers. The present collection of papers is one of that type.

The phonetic research has not sufficiently developed in our country. The phonetic features for Indian languages are set up on *ad-hoc* basis, as they have not been established concretely on the basis of pure research. The CIIL has made a modest beginning by getting its staff trained abroad and by organizing the phonetic Institutes for the junior staff of the universities and the research scholars. It is hoped, that in course of time, a band of motivated and devoted phoneticians in India would be developed. Only after that, we can expect a serious phonetic description of Indian languages. The meeting of phonetic experts in India was called in June 1983, and one of the recommendations of the meeting was to organize two Summer Institutes in 1984 and 1985. *Acoustic Studies in Indian Languages* is an outcome of research done during the Summer Institute in Advanced Phonetics in 1984.

Segmental and suprasegmental phenomena have been studied in the present volume. It is also planned to study the voice quality and try voice identification for academic purposes. It is also planned to extend the scope of experimental phonetics to computer analysis and try the synthesis of speech through computer, while keeping up the earlier methods of experimental phonetics in their strong areas.

I hope that the present volume will be taken in good spirits and constructive suggestions for advanced phonetic research would be given.

E. ANNAMALAI

EDITORIAL

A meeting of Indian Phoneticians, which was called by the CIIL in June 1983, strongly felt the need to stimulate the phonetic research in India and recommended two Summer Institutes for imparting basic and advanced training to the interested university staff and research scholars in phonetics. Accordingly, a Summer Institute in Advanced Phonetics was organised in the summer of 1984 and another Summer Institute in Experimental Phonetics is proposed to be organised in the summer of 1985. It would be appropriate to recall here that an International Institute in Phonetics was organised by CIIL in 1981 with the international faculty and participants. The proceedings of that Institute have been published under the title *Papers in Phonetics and Phonology*. The papers presented in this collection were worked out during the Summer Institute in Advanced Phonetics, 1984.

There were twentynine participants representing 17 Indian languages/dialects. Out of these fifteen analyses are presented here. Two analyses could not be completed. The participants were divided into three groups:

Group I : Segmentals - supervised by Dr. P. Bhaskar Rao and Dr. R.C. Garg.

Group II : Suprasegmentals - supervised by Dr. B.S. Sandhu, Dr. M.R. Ranganatha and Dr. B.B. Rajapurohit.

Group III : Acoustic Phonetics - supervised by Dr. K. Murugaiyan and Dr. Nagamma Reddy.

All the analyses in all the three groups were done from acoustic point of view. The equipment which was pressed into service was the sound spectrograph of Kay Elemetrics Corporation, U.S.A. However, one analysis was done on the Pitch Analyser at the All India Institute of Speech and Hearing, Mysore. It may be said that an attempt was made to solve the segmental and suprasegmental problems with the help of sound spectrograph. The findings throw light on the phonetic facts of languages/dialects.

It may be noted that within a course of three weeks of the Summer Institute, an area for phonetic investigation had to be identified, the experiment had to be designed, the readings/measurements had to be taken and the results had to be presented after analysis. During this operation the training in theoretical and practical phonetics continued. It should be confessed that the results arrived at are not conclusive, but they do open up new areas of phonetic investigation.

Small problems from 15 Indian languages/dialects are taken for investigation here. The results arrived at, even though they are based on a limited data, bring forth interesting facts about the languages/dialects. Hence, it was decided to share them with a larger fraternity of linguists and phoneticians.

The studies of the "Quality of Vowels" in five languages have brought out interesting observations. In Assamese /a/ is [ʌ] when the preceding consonant is voiced and the following one is voiceless; it is [ə] when both the preceding and the succeeding consonants are voiced. The allophonic distinction brought out by the present acoustic study should be subjected to further tests. In Oriya, the characteristic difference between /i/ and /e/ is the forward-backward movement of the tongue rather than the height of the tongue. If this point is confirmed by larger experiments then this point will have to be considered while describing the distinctive features of Oriya vowels.

There is a lot of uncertainty about the intervocalic voiceless consonants in Tamil, which has been studied in another paper. Marathi has a set of eight affricates, which have been studied for duration and other acoustic features. The relative duration of five Urdu voiceless fricatives has been determined in yet another paper. The least studied liquids have been examined in Kannada, with a view to studying the relationship between single and geminated sounds. Malayalam has two trills in its alphabet. Their phonetic quality is tested here. Aspiration and its relationship with /h/ have been studied in two other papers. The suprasegmentals, tones, and intonation phenomena are also studied in five of the papers.

An attempt is made to study a variety of problems. If the results presented here could inspire further research, the authors of the individual papers, their supervisors and the editor, would feel gratified. The Central Institute of Indian Languages would feel rewarded for the task undertaken.

B. B. RAJAPUROHIT

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The inspiration and the moral support given by Dr. E. Annamalai, Director, CIIL, are thankfully acknowledged. The members of the faculty of the Summer Institute in Advanced Phonetics 1984 - Prof. R.N. Srivastava, Prof. B.S. Sandhu, Prof. P. Bhaskar Rao, Dr. K. Murugaiyan, Dr. R.C. Garg, Dr. (Mrs.) Nagamma Reddy - worked without remuneration, for the cause of promoting phonetics in India. Our heartfelt thanks are due to them. Dr. M.R. Ranganatha, who also worked as a member of the faculty, gave a helping hand; Dr. G.V. Natarajan, gave the organizational assistance; the Language Laboratory Technicians, particularly Sri R.Nagaraj, bore the major work of Spectrograph; Sri H.L.N. Bharati has seen the book through the press; Sri N.H. Itagi has designed the cover as he did for two earlier books, to all these hearty thanks are due. The Principal, Maharaja's College, Mysore, provided the hostels for the men participants of the Summer Institute in Phonetics. The Director, All India Institute of Speech and Hearing, made arrangements for the services of the Pitch Analyser and provided the hostel facilities for the women participants. Their help is thankfully acknowledged.

B. B. Rajapurohit

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VOWEL LENGTH IN ASSAMESE

Basanti Devi

This study is carried out with the help of spectrographic analysis to see if voicing has any impact on the length of vowels in Assamese.

Assamese has eight vowel phonemes which are tabulated below:

	Front	Central	Back
High	i		u
High-mid	e		o
Low-mid	ɛ		o
Low		a	

All the eight vowels occur in all the three positions, viz., Initial, Medial and Final. The eight way contrast of the vowels can be illustrated with the help of the following words.

bis	'to fan'	bes	'nice'
bɛs	'to sell'	bas	'to choose'
kɔla	'deaf, art'	kola	'black'
kóla	'lap'	kula	'winnowing fan'

These vowel phonemes, however, do not have their longer counterparts. In other words Assamese does not maintain distinction between long and short vowels at phonemic level. Upendra Nath Goswami maintains that there is no distinction between short and long vowels. Golok Chandra Goswami states 'all vowels have different degrees of length, which are allophonic according to their position of occurrence in a word'. In this short experiment, hypothesis that the voicing of the preceding or the following consonant influences the length of the vowel, has been tested. Keeping in mind the limitations of such a study we have restricted ourselves to the following data.

Table 1

	Set A	Set B	Set C	Set D
/i/	pit 'to beat'	bit 'beetroot'	gil 'swallow'	pira 'wooden seat without leg'
/e/	petu 'intestine'	bet 'to bet'	gelil 'has spoilt'	pera 'a kind of sweet meat'
/ɛ/	pɛt 'stomach'	bɛt 'care'	gɛl 'to spoil'	pɛra 'box'
/a/	pat 'to establish'	bat 'path, way'	gal 'cheeks'	para 'mercury'
/ɔ/	pɔt 'appearance'	gɔt 'style, way'	gɔl 'neck'	pɔr 'to face'
/o/	poti 'name of a girl'	goti 'motion'	gol 'has gone'	pori 'fairy'
/ó/	pot 'to bury'	gót 'unit'	gól 'round'	pór 'to burn'
/u/	puti 'having buried'	guti 'seed'	guli 'reel of thread'	puri 'one variety of snacks'

In Set A, the vowels are preceded and followed by voiceless stops; in Set B, the vowels are preceded by voiced stops but followed by voiceless ones. Vowels in Set C are preceded and followed by voiced consonants. The vowels in Set D are preceded by voiceless consonants but followed by the voiced ones.

As a first step of our investigation articulatory and auditory tests were conducted by the above data. Each phoneme was uttered four times in four different environments. Articulatory feeling and auditory tests have given clues that vowels have a tendency to get slightly lengthened in the environment of voicing.

The next step was to take spectrograms of the words contained in the above list. Because of the non-availability of native speakers only one token could be taken. Thus spectrographic analysis was restricted to the front vowels only. However, all the four environments shown in Table 2 were taken into consideration.

The results of the words in Set A are shown below:

Set A

Table 2

	F_1	F_2	Duration
pit	400	2700	100
petu	500	2400	100
pɛt	600	2200	160
pat	700	1500	150

Frequency of the formants of the vowels in the environment of preceding and following voiceless consonants, was measured. Duration of the vowels is measured in milliseconds. The duration of the low vowels is longer than that of the high vowels. The average duration of vowels in Set A is 127.5 m/secs.

Set B

Table 3

	F_1	F_2	Duration
bit	400	2700	100
bet	500	2500	150
bɛt	600	2000	150
bat	500	1300	160

The above Table shows the results of words in Set B where the preceding consonant is voiced and the following one is voiceless. Slight variations are noticed in the formant figures. Compared to Set A, F_1 and F_2 of the vowel /a/ are low here which is below the normal standard. This means that the /a/ is having raised but retracted articulation very near to [ʌ]. As regards the duration, major change is noticed in case of /e/ only. It is 50 m/secs. more when compared with /e/ in Set A. Other variations are minor. Average duration is 140 m/secs.

Set C

Table 4

	F_1	F_2	Duration
gil	500	2800	110
geli	500	2500	110
gɛl	600	2000	160
gal	600	1500	160

The above Table gives the figures for the words in Set C. The formant structures are found to be consistent. The duration figures are also fairly consistent when compared with Set B.

But when compared with Set A, slight increase in F_1 and F_2 is noticed in case of /i/. This means that /i/ is lower in this environment. The F_1 figures for /a/ are lower which means that /a/ is moving towards /ə/ in this environment. Average duration is 135 m/secs.

Set D

Table 5

	F_1	F_2	Duration
pira	400	2600	120
pera	500	2500	140
pɛra	700	2000	150
para	700	1400	120

In the above Table no major change in the formant figures has shown up. They are very much comparable with figures in Set A. A slight variation is noticed in the case of /ɛ/. F_1 of /ɛ/ is higher here than in Sets A, B and C. This means that /ɛ/ is as much low as /a/ in this environment. /ɛ/ is a fronted articulation whereas /a/ is a central articulation. Average duration is 132 m/secs, which is higher than that of Set A but lower than that of Sets B and C.

Though it may not be possible to establish something firmly the results are showing the symptoms of the tendencies of shift in vowel quality on account of environments. The following observations may be made:

(i) The average duration of Set A is 127.5 which is the lowest and that of Set B is 140 which is the highest in all the four sets.

(ii) The average figures of duration in Set C indicate that the vowel length does not show any significant change when the vowel is preceded and followed by voiced sounds.

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A SPECTROGRAPHIC STUDY OF BENGALI VOWELS

Subhra Basu-Ghosh

Though in Bengali alphabetic system twelve vowel symbols (viz., a, ā, i, ī, u, ū, ṛ, ḷ, e, ai, o, au) are used, the standard colloquial Bengali is considered to have only seven oral vowel phonemes (Chatterji, 1975). These are: /i, e, æ, a, ɔ, o, u/.

Since a number of studies have already been made in the area of articulatory phonetics, it was intended to attempt an acoustic analysis of the quality of the Bengali vowel sounds and their duration. The quality is determined on the basis of the frequency readings of the formants.

The data were recorded on professional tape recorders in the studio of CIIL. The wide-band spectrograms were taken on the Sonagraph model 6061B manufactured by the Kay Elemetrics Corporation, USA, with a frequency range of 80-8000 Hz. The measurement of formant frequencies was taken with the help of a scale designed by CIIL.

The Bengali vowel sounds in isolation and in words in different environments were pronounced for the recording by Mr. S. Barman, who speaks Standard Colloquial Bengali (SCB) as his mother tongue SCB is that variety which is spoken in and around Calcutta.

List of Words:

iṭ	'brick'	čik	'curtain'
ki	'what'	eta	'it'
neśa	'addiction'	ke	'who'

æto	'so much'	kæno	'why'
jæ	'bow string'	ata	'a kind of fruit'
baba	'father'	čhata	'umbrella'
tɔ	'that quantity'	ghɔno	'thick'
śɔ	'hundred'	ogo	'hallow'
kon	'which'	po	'son'
uṭ	'cammel'	čul	'hair'
kocu	'arum'		

Results of the Analysis:

The readings of the formant frequencies are tabulated below:

Table 1 : Formant Frequencies of Vowels in Isolation

Vowel	F_1	F_2	F_3
i	250	1900	2500
e	300	1850	2400
æ	600	1500	2200
a	700	1100	2300
ɔ	400	900	1300
o	400	850	2400
u	250	800	1350

Table 2 : Formant Frequencies of Initial Vowels

Vowels	F_1	F_2	F_3
i	200	2000	2500
e	350	1900	2200
æ	550	1425	2300
a	600	1200	2150
ɔ	550	1000	2400
o	350	800	2250
u	300	700	2150

Table 3 : Formant Frequencies of Medial Vowels

Vowel	F_1	F_2	F_3
i	200	2000	2400
e	300	1850	2350
æ	400	1500	2000
a	550	1050	2000
ɔ	500	1050	2200
o	350	800	2500
u	250	850	2100

Table 4 : Formant Frequencies of Final Vowels, and Average of F_1 and F_2 in all Positions

Vowel	F_1	Average of F_1 in all positions	F_2	Average of F_2 in all positions	F_3
i	250	*225*	1900	*1950*	2600
e	400	*325*	1850	*1865*	2500
æ	500	*515*	1400	*1455*	2000
a	600	*615*	1100	*1115*	1950
ɔ	450	*475*	850	*950*	2100
o	400	*375*	750	*800*	2190
u	300	*275*	800	*785*	--

For acoustic study the first two formants (F_1 and F_2) are of relevance, as they are enough to determine the vowel quality. The relative positions of seven Bengali vowels based on the averages of F_1 and F_2 figures of vowels in different positions are shown in the graph at the end.

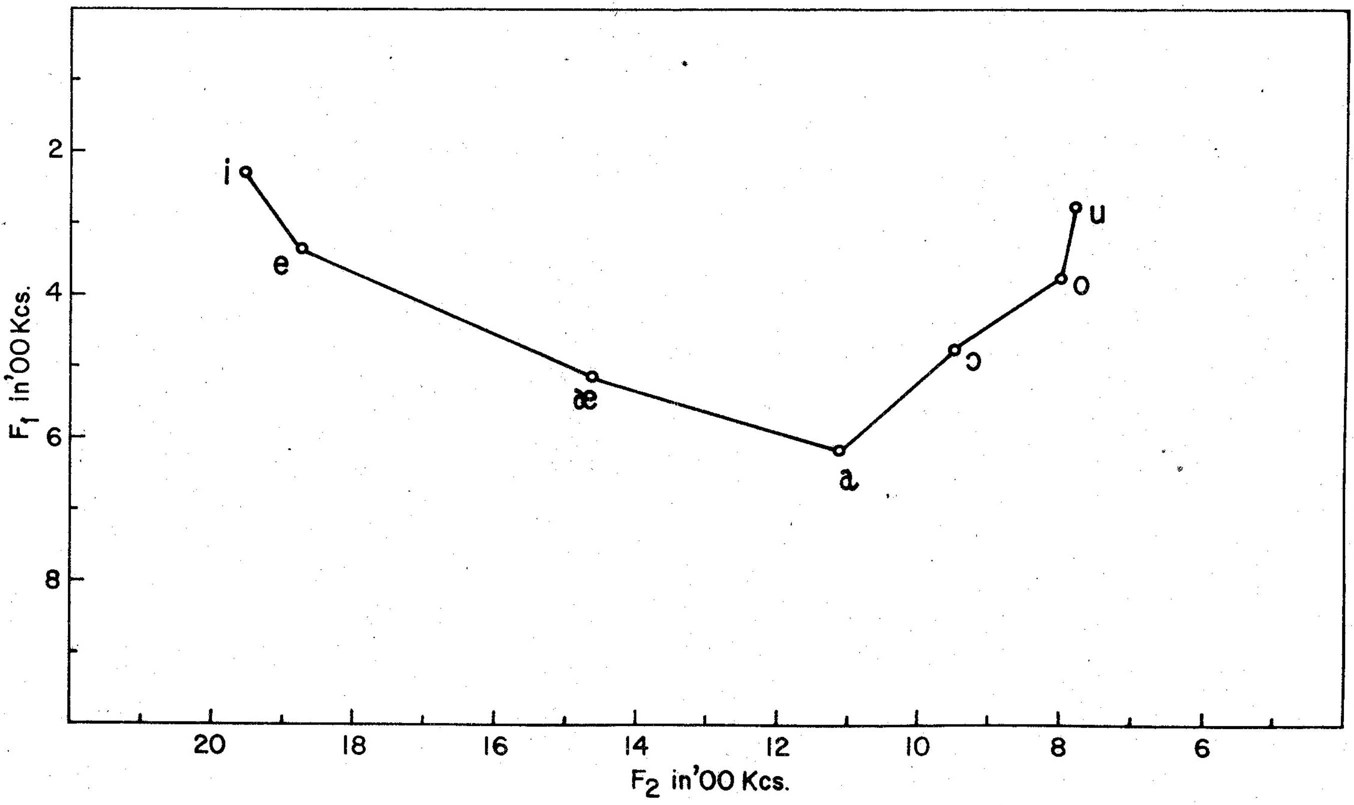
It is an accepted phenomenon that F_1 indicates the height of the tongue, i.e., higher the tongue the lower the F_1 and lower the tongue the higher the F_1. F_2 indicates the forward-backward movement of the tongue, i.e., higher the F_2 fronter the tongue and lower the F_2 backer the tongue. This feature has been displayed by the graph. As the average figures bring out, /u/ is slightly lower than /i/ in the tongue height. /ɔ/ is not as much back as /u/ or /o/ and /a/ is higher in tongue position when compared to many other languages. For the front vowels F_1 and F_2 have a large distance (vide anti-formants), whereas in case of back vowels the F_1 and F_2 are much closer (narrow anti-formants). With these brief observations on the relative tongue positions of the Bengali vowels we may say that the present spectrographic investigation considerably modifies traditional diagram of the vowel triangle (vide: graph).

Duration of Vowels:

Table 5 : Duration (in m/secs.) of the Vowels in Different Positions and Their Average (in Round Figures)

Vowel	Isolation	Initial	Medial	Final	Average
i	380	190	150	170	222
e	390	100	145	200	209
æ	360	120	110	200	222
a	320	130	120	130	175
ɔ	350	110	155	170	196
o	350	130	165	200	211
u	250	180	155	100	171

It can be seen from the above Table 5 that the minimum and maximum duration figures of vowels in isolation are longer than those of the vowels in the other positions. On the average /u/ has the shortest duration and /i/ and /æ/ have longest duration.



Quality of Bengali Vowels

Becuase of the isolation figures the average figures of short vowels are much higher than the corresponding figures in other languages. The above acoustic study of vowels largely agrees with the traditional description of vowels in terms of tongue height and the part of the tongue involved during their production though some modifications have been brought out as noted earlier.

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of the formant frequencies and the duration of vowels were taken in order to arrive at the absolute acoustic properties.

A system of seven vowels has been accepted for the present study. These are: /i, e, æ, a, ɔ, o and u/. On the basis of the results of the present analysis they may be described as follows:

/i/

Bengali vowel /i/ occurs in the initial, medial and final positions of the words. According to the conventional phonetic description, Bengali vowel /i/ is a front, high and spread vowel. But the acoustic analysis of the vowel shows that it is not too much a front vowel - it is slightly centralised. But still it is fronter than the vowel /e/. The acoustic energy in the production of /i/ is distributed as follows: the first formant appears at 275 Hz, the second fromant appears at 1975 Hz and the third formant is placed in 2625 Hz. Average duration of this vowel is 247.51 milliseconds.

/e/

One of the seven Bengali vowels, vowel /e/ occurs in the initial, medial and final positions of the words. From acoustic observations this vowel may be classified as a front, high-mid and spread vowel. This distribution of the acoustic energy during the articulation of this vowel is as follows: the first formant is found at 350 Hz, the second formant is located at 1850 Hz, and the third formant is situated in 2450 Hz. The duration of /e/ is 185 m/seconds.

/æ/

The vowel /æ/ in Bengali occurs in the initial, medial and final positions of the words. Acoustic analysis of this vowel attests that this is a front, low-mid and spread vowel. Spectrographic analysis of this vowel shows that the first formant is situated in 525 Hz, the second formant is prominent and is situated at 1850 Hz and the third formant is located at 2225 Hz. Its average duration is 177.5 m/seconds.

/a/

Bengali vowel /a/ occurs in the initial, medial and final positions of the words. This vowel, from acoustic findings may be classified as a central, low and spread vowel. Spectrograms of this vowel show that the first and the second formant are mixing with each other. The first concentration of (formant) acoustic energy lies at 637.5 Hz, the second concentration (formant) at 1237.5 Hz. and the third at 2212.5 Hz. Duration of this vowel on an average is 185 milliseconds.

/ɔ/

Occurs in the initial, medial and final positions of the words. It may be described as a back, low-mid and partly rounded vowel. Acoustic analysis of this vowel shows that the concentrations of acoustic energy in the form of the three formants are as follows: first formant 475 Hz, second formant 1025 Hz, and the third formant 2300 Hz. Duration of /ɔ/ is 185 milliseconds.

/o/

Bengali vowel /o/ appears in the initial, medial and final positions of the words. It may be classified as a back, high-mid and rounded vowel. Acoustic analysis of this vowel by means of the spectrograph reveals that the first formant is located at 400 Hz, the second formant at 862.5 Hz, and the third formant at 2250 Hz. Duration of this vowel is 175 m/seconds.

/u/

Is a vowel in Bengali which occurs in the initial, medial and final positions of the words. This vowel is conventionally recognised as a vowel, which is high, back and rounded. But the results of the present analysis differ from this description to some extent. The present analysis shows that /u/ is not purely a back and high vowel, but it has a tendency to be slightly centralized and lower than the cardinal /u/. Instead of /u/ being backer than /o/ as expected, it is fronter in the present study. This observation needs to be investigated further. Acoustic analysis of this vowel shows that the frequencies associated with the three formants are: 300 Hz for the first formant, 900 Hz for the second formant, and 1800 Hz for the third formant. Duration of this vowel is 135 m/seconds.

On the basis of the brief study, the summary of the acoustic characteristics of Bengali vowels may be given as follows: All Bengali vowels, while they occur in different environments, their formant frequencies differ slightly in different positions. This variation of frequencies has been shown in Tables 1, 2, 3 and 4. According to the environment and position of occurrence, Bengali vowels may be short or long as the duration figures in Tables 1 to 4 indicate. But vowel length is not phonemic in the language, as it is indicated by the duration figures in Table 5. Except /i/, which shows about 30% additional average duration over the other vowels and /u/ which has about 30% lower duration that the average, the other vowels show up with comparable average duration, /i/ and /u/ also show an increase or decrease of only 30% of duration which could be ascribed to the idiosyncrasy of the author's pronunciation. Further, it may be observed that the vowels before and after voiced and aspirated consonants in the initial and final syllables of polysyllabic words are a bit longer. This variation of vowel length have been shown in the Tables 1 to 4. Each of the seven Bengali vowels has its nasalised counterparts and sometimes contrasts with the oral vowel. That is the nasalization of a vowel is not contrastingly maintained by the present Bengali native speakers, and hence, it has now-a-days lost its phonemic value in the language. However, this feature could not be tested acoustically in the present experiment.

Table 1 : Showing the Formant Frequency and Duration of the Vowels Spoken in Isolation

Vowels	F_1	F_2	F_3	Duration in m/secs.
i	250	2000	2650	330
e	350	1850	2300	350
æ	500	1000	2400	320
a	750	1250	2300	300
ɔ	450	800	2300	350
o	400	850	2400	350
u	300	800	1400	250

Table 2 : Showing the Formant Frequency and Duration of the Vowels Spoken in the Initial Position of Words

Vowels	F_1	F_2	F_3	Duration in m/secs.
i	350	2000	2600	200
e	350	1900	2600	90
æ	550	1450	2300	90
a	700	1200	2200	170
ɔ	500	1100	2500	90
o	400	800	2500	80
u	350	1000	--	90

Table 3 : Showing the Formant Frequency and Duration of the Vowels Spoken in the Medial Position of Words

Vowels	F_1	F_2	F_3	Duration in m/secs.
i	250	2000	2600	220
e	350	1800	2400	100
æ	500	1500	2100	100
a	650	1250	2250	160
ɔ	450	1200	2200	100
o	400	900	2200	150
u	300	850	2000	80

Table 4 : Showing the Formant Frequency and Duration of the Vowels Spoken in the Final Position of Words

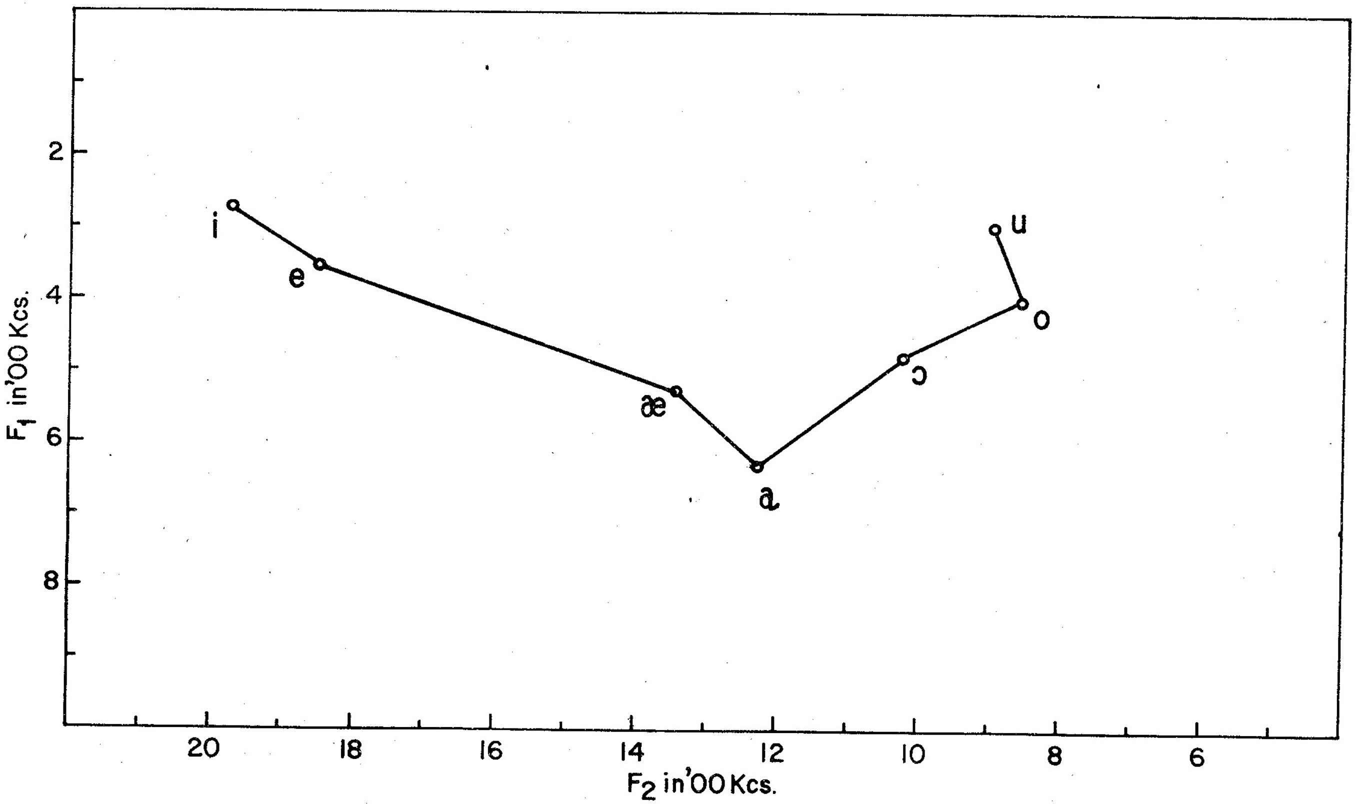
Vowels	F_1	F_2	F_3	Duration in m/secs.
i	250	1900	2650	220
e	350	1900	2500	200
æ	550	1450	2100	200
a	450	1250	2100	110
ɔ	500	1000	2200	200
o	400	900	2200	120
u	250	950	2000	120

Table 5 : Showing the Average of the Formant Frequency and Duration of the Vowels Spoken in Different Environments

Vowels	F_1	F_2	F_3	Duration in m/secs.
i	275	1975	2625	247.5
e	350	1850	2450	185
æ	525	1350	2225	177.5
a	637.5	1237.5	2212.5	185
ɔ	475	1025	2300	185
o	400	862.5	2250	175
u	300	900	1800	135

/iṭ/ 'brick'	/kit/ 'insect'	/ki/ 'what'
/eta/ 'this'	/peśa/ 'profession'	/ke/ 'who'
/æto/ 'this quantity'	/kæno/ 'why'	/hæ/ 'yes'
/am/ 'mango'	/ǰam/ 'berry'	/paka/ 'ripe'
/to/ 'that quantity'	/jɔto/ 'whatever quantity'	/so/ 'hundred'
/ojon/ 'weight'	/kon/ 'which one'	/kalo/ 'black'
/uču/ 'high'	/khuku/ 'little girl'	/niču/ 'low'

The following graph would present the vowel triangle of Bengali.



Quality of Bengali Vowels

Note: There is a shift in the quality of æ and u in the two studies of Bengali vowels. This is due to the different words taken. The phonetic context is also responsible —Ed.

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DURATION AND QUALITY OF ɨ, ə, a IN KASHMIRI

Gopi K. Kantroo

Introduction

The following studies of Kashmiri are worth mentioning at the outset.

Bailey (1937) described the sounds of Kashmiri and suggested accurate and elaborate method of transcription. This work was meant to serve as a guide to learn spoken Kashmiri.

Firth (1939) made a similar attempt to give a specimen transcription of the Kashmiri text and also gave a tentative analysis of the Kashmiri sounds.

Morgenstierne (1941) besides reviewing the earlier works on Phonetics and Phonology presented an exhaustive study of Kashmiri speech. Though he dealt with some phonological aspects of the language for the first time, his transcription is quite complicated.

Kelkar and Trisal (1964) have discussed the Kashmiri word phonology at some length. This seems to be the first serious attempt to study Kashmiri phonology.

Verma (1964) discusses the syllabification in Kashmiri language.

Kachru (1969) touches, almost all the basic levels of the language which a grammar of this type promises.

Kachru (1973) is an authentic work, very useful for the second language learners/teachers of Kashmiri.

Handoo (1973) seems to be in complete agreement with Kachru (1969) in the Phonetic description of language.

Koul (1977) makes a successful attempt to explore the syntactic structure of Kashmiri. A very recent study on Kashmiri Phonology has been made by Dr. Boris Zakhryin. The book is in Russian and not available outside USSR. Hence its contents remain inaccessible.

Besides the above cited studies there are some institutions and other organizations which are actively engaged in producing books, other materials and research work in Kashmiri. They include (1) The Academy of Art, Culture and Languages, Srinagar. They have produced two bilingual dictionaries: (i) Kashmiri to Kashmiri and (ii) Urdu to Kashmiri, in several volumes. However, they seem to be more interested in Literature than in Linguistics. (2) The Vishweshwaranand Vedic Research Institute, Hoshiarpur, is also engaged in the lexical study of Dard and Pahari languages including Kashmiri and (3) The Central Institute of Indian Languages, Mysore and its Northern Regional Language Centre, Patiala, have produced several materials like: Basic, Intermediate and Advanced Courses of Kashmiri, Kashmiri-Hindi Common Vocabulary, Kashmiri Glossary, State-School Reader in Kashmiri, and Spoken Kashmiri.

Kashmiri though listed in the eighth schedule of the Indian Constitution as one of the recognized regional languages, has not been given its proper place in the State of Jammu and Kashmir. It is neither the official language of the State nor a medium of instruction in the schools. It has not found a regular place in the academic curriculum of the State, and this is the reason why there has been no need of writing textbooks, etc., in this language at the State level.

Inventory of Vowel Phonemes

The phonemic system of Kashmiri is made up of fifteen vowels:

	Front unrounded		Central unrounded		Back rounded	
High	i	i:	ɨ	ɨ:	u	u:
Mid	e		ə	ə:	o	
Lower: Mid	e:		a		o:	
Low			a:		ɔ	

Kachru (1969) and Handoo (1971), have established the longer counterpart of the low-back vowel /ɔ/ as /ɔ:/ in their studies and both of them have supported the vowel with an isolated example in the language: /sɔ:d/ 'one and a quarter'. I do not find an adequate justification for retaining this vowel in the current vowel inventory and moreover the example cited to justify it, is not an original Kashmiri gloss. It has been borrowed into Kashmiri very recently. I would rather prefer to transcribe it as /sɔa:d/ rather than /sɔ:d/.

Phonetic Description

All the speech sounds in Kashmiri including the consonants are produced with egressive lung-air. That is, while producing the vowels the air stream is made to pass through the oral cavity without any obstruction.

The front and central vowels are unrounded and the back vowels are rounded. Generally there is less rounding of the lips in back vowels and less spreading of the lips in all unrounded vowels, except /a/ and /a:/. Central high and mid vowels /ɨ, ɨ:, ə, ə:/ are quite tense.

For the present study three central unrounded, high, mid and low-mid vowels /ɨ, ə, a/ were selected to check the frequency and duration in the medial position. The vowel /ɨ/ occurs medially and finally whereas /a/ and /ə/ occur in all the positions in Kashmiri.

The Articulatory Description

/ɨ/ : While producing this sound, the vocal cords vibrate so as to produce voicing, the soft palate is raised closing the velic passage to the nasal cavity, the middle of the tongue is raised towards the hard palate to such a height that the air current passes without any obstruction or friction and the lips are slightly spread. This is called high central unrounded short vowel.

/ə/ : While producing this sound, the vocal cords vibrate to produce voicing and the soft palate is raised closing the velic passage to the nasal cavity. The middle of the tongue is raised towards the roof to mid height for the production of this vowel (it is not as high as in case of /ɨ/). This height of the tongue is normally called the neutral position. In the articulation of this vowel the lips remain in the neutral position. This is known as mid central unrounded short vowel.

/a/ : While producing this sound the vocal cords vibrate to produce voicing, the soft palate is raised to close the velic passage to the nasal cavity, the tongue remains in a relaxed position or low position; mouth remains open and the lips spread or in the neutral position. This is known as low central short vowel.

Acoustically it is found out that while pronouncing the vowels /ə/ and /a/, there is some fronting character than the vowel /ɨ/ which is shown in a graph at the end.

Duration and Formant Frequencies

Vowel	No. of tokens	Duration in m/secs.			Average		
		Minimum	Maximum	Average	F_1	F_2	F_3
					Hz	Hz	Hz
/ɨ/	4	160	180	172.5	500	1250	2250
/ə/	8	120	200	158.75	700	1350	2288
/a/	8	110	160	137.5	800	1350	2325

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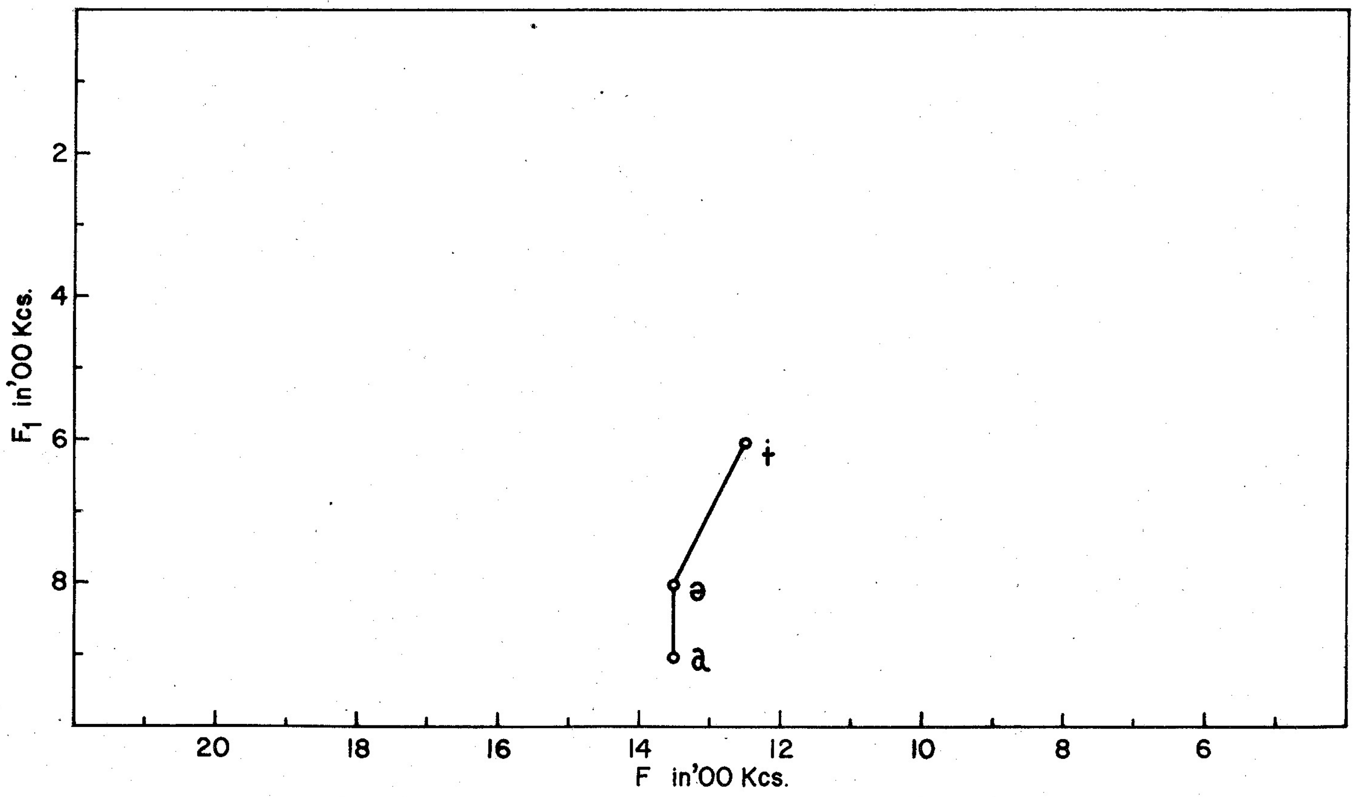

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A SPECTROGRAPHIC STUDY OF ORIYA VOWELS

Devaraj Panda

0. Introduction

Oriya is the principal language of the State of Orissa and is spoken by 26,370,271 people (Census, 1981). It is a member of Eastern (or Magadhan) Group of Indo-Aryan languages. The date of origin of Oriya language, although is a controversial issue, (see Gouldslurry, 1850-51; Grierson, G.A., 1927; Praharaja, G.C., 1930; Pattanayak, D.P., 1958; Das, N., 1959, Hota, S., 1961; Tripathy, K.B., 1962; Sahoo, K.C., 1982), has been set on the basis of available literature at as far back as the eleventh century A.D. (see Panda, 1983).

The standard Oriya dialect possesses six vowels and thirtyone consonants (Pattanayak, D.P., 1970; Pattanayak, D.P. and Das, G., 1972; Panda, D., 1983). According to Pattanayak and Das (1972) there is no length contrast between vowels in Oriya as in other Indian languages, particularly Dravidian, but they have pointed out that there are a few cases of vowel sequences in the language.

The present study aims at providing the acoustic characteristics of vowels in terms of formant frequencies and their duration which has not been done so far for Oriya.

The data consists of six vowels spoken in isolation as well as in the word initial, medial and final positions as shown below.

In isolation:

i, e, a, ɔ, o and u.

In words:

Initial		Medial		Final	
iṭa	'brick'	kisɔ	'what'	asi	'coming'
eṭa	'this'	kesɔ	'hair'	ase	'comes'
aṭu	'roof'	kasɔ	'cough	asa	'hope'
aṭu	'are'	kɔsɔ	'measure'	asɔ	'come'
ɔṭɔ	'is'	kosɔ	'store'	so	'sleep'
oṭɔ	'camel'	kusɔ	'a plant'	asu	'let him come'
oṭhɔ	'lip'				
uṭhɔ	'get up'				

1. Experiment

The data were recorded in a sound proof studio of the Central Institute of Indian Languages, Mysore, by the author who represents standard Oriya dialect spoken in the district of Puri.

The wide-band spectrograms of the vowels in words and in isolation were made by using the sound spectrograph 6061B manufactured by M/s. Kay Elemetrics, at the Phonetics Laboratory of CIIL, Mysore. Spectrograms were made at 80-8000 frequency range.

The measurements of the centre of the formant frequencies of vowels were taken in milliseconds, and are summarised in Tables 1 to 4.

Table 1 : Formant Frequencies and Duration of Vowels in Isolation

Vowels	F_1 Hz	F_2 Hz	F_3 Hz	Duration in m/secs.
i	250	2000	2700	360
e	300	1700	2350	400
a	650	1200	2400	370
ɔ	400	750	2300	350
o	300	600	2400	330
u	250	600	3600	220

VOWEL QUALITY IN BENGALI

Satyendra Nath Barman

Bengali, the state language of West Bengal in India and of Bangladesh, belongs to the Eastern group of Indo-Aryan languages. Modern Bengali has at least five well marked dialects. The standard colloquial Bengali is a modified and cultivated form of West-Central sub-dialect to which area the metropolitan city of Calcutta belongs. The present study of the vowel quality is based on the data from standard colloquial Bengali.

Bengali vowels have been analysed by many linguists. Following the Sanskrit grammarians, the traditional grammarians of Bengali language have recognised twelve vowels. In the later era, most of the lingusts, except Muhammad Abdul Hai, have recognised seven vowels in Bengali. Muhammad Abdul Hai has recognised eight vowels.

Since many of the works, except that of Kostić and Das, are based on articulatory and auditory phonetics. Extensive acoustic studies of Bengali vowels are yet to be made. The present paper is an attempt to study the quality of Bengali vowels from acoustic point of view. Kostić and Das, however, have done the preliminary acoustic analysis of Bengali.

Data for the present study were recorded by the present author whose mother tongue is Bengali. Wide-band spectrograms were taken on the basis of single token for each item. The vowels were spoken in four different positions: in isolation and in the initial, medial and final positions of words. The averages

Table 2 : Formant Frequencies and Duration of Vowels in the Initial Position

Vowels	F_1	F_2	F_3	Duration
i	200	2000	2600	90
e	300	1700	2400	100
a	500	1250	2150	90
ɔ	400	1000	2150	80
o	300	650	2500	100
u	200	600	2600	80

Table 3 : Formant Frequencies and Duration of Vowels in the Medial Position

Vowels	F_1	F_2	F_3	Duration
i	250	1800	2500	70
e	300	1550	2400	80
a	500	1200	2100	100
ɔ	450	950	1700	105
o	350	850	1700	85
u	250	800	--	60

Table 4 : Formant Frequencies and Duration of Vowels in the Final Position

Vowels	F_1	F_2	F_3	Duration
i	250	1800	2500	200
e	300	1600	2400	180
a	500	1250	2300	170
ɔ	450	950	1600	180
o	350	800	1500	260
u	250	800	--	160

2. Results and Discussion

(a) Quality: The front vowels have higher F_2 than the back vowels and the distance between F_1 and F_2 of front vowels is longer than that of the back vowels. F_3 of all the vowels is visible in isolated position. But the F_3 of the back vowels except 'u' (in some cases) is visible in the medial and final positions. In isolation F_3 for the back vowels is higher than that of the front vowels.

When the frequency figures of F_1 and F_2 are plotted on graph it is observed that the formants of certain vowels seem to be not agreeing with the conventional quality. For example, the distinction between /i/ and /e/ is one of the forward-backward movement of the tongue rather than the height of the tongue. Other relationships are evident from the graph.

(b) Duration: Vowels in isolation are evidently longer than the vowels in the initial, medial or final position. On the other hand vowels in the medial positions are shorter than in the initial positions. The half close vowels are longer than the close vowels (except in the final position), where /i/ is longer than /e/.

3. Conclusion

Spectrographic analysis of Oriya vowels, though brief, reveals a consistent and considerable difference in quality as well as in duration. From the fromant Tables it is evident that the tongue moves to the highest position for the production of /i/ and /u/ and to the lowest position for the production of /a/. For the production of /e/ and /o/ the tongue moves downward from the highest position and again it moves further downward for /o/. But for /i/ and /u/ the front and back part of the tongue maintain the same height in isolation, medial and final positions but it moves a little bit higher in the initial position. For /e/ and /o/ the tongue maintains the same level of height in all the positions. The level of /ɔ/ is also the same in all the positions but the level of /a/ is more low in the case of isolated occurrence, than in the other positions. The vowels on an average have 338 m/secs. duration in isolation and 80 m/secs. in the initial and medial positions and 191 m/secs. in the final position.

From the above study, it may be concluded that acoustically all the six vowels contrast supporting the phonological analysis of Oriya vowels, with a change in the placements of these vowels in a vowel triangle.

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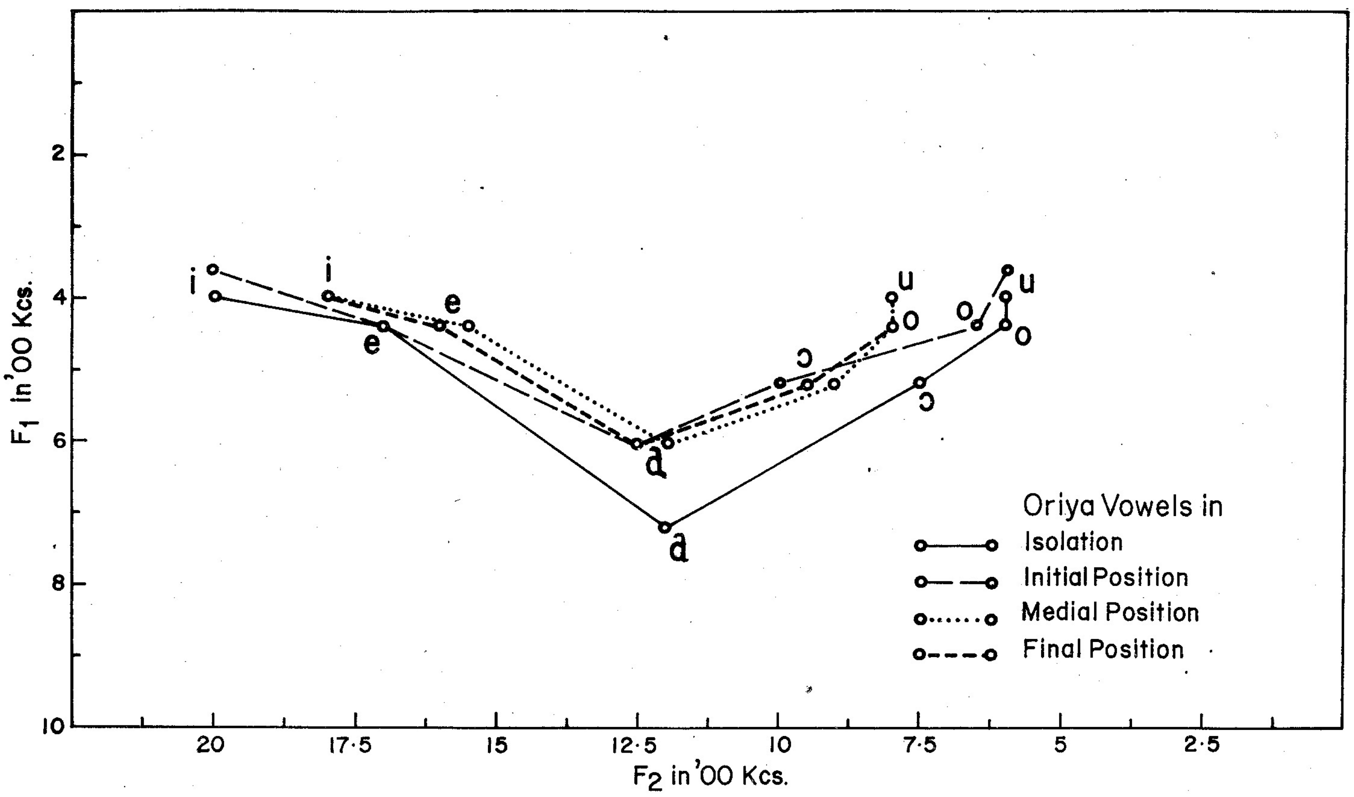

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INTERVOCALIC /t, ṭ, č/ IN TAMIL

Saroja Ramakrishnan
G. Balasubramanian
A. Nallaswamy

This paper represents an attempt to integrate some new findings with the previously published information on the description of the intervocalic /t, ṭ, č/ in Tamil. According to some scholars (Ramaswamy and Asher), the intervocalic /t/ is described as [đ] (a voiced dental fricative), the intervocalic /ṭ/ as [ṛ] (a voiced retroflex flap) and the intervocalic /č/ as [ǰ] (a voiced palatal affricate).

For [đ] (voiced dental fricative) the tip of the tongue is raised towards the upper teeth and makes a close slit. The pulmonic air-stream passes through that narrow constriction with friction and creates an audible noise. While the air passes through the oral cavity thus, the vocal folds are also vibrated, as it is a voiced sound.

For [ṛ] (voiced retroflex flap) the sound is produced when the sub-lamina of the tongue is raised and curled upwards and back and falls forward onto the floor of the mouth sweeping through the teeth-ridge on its way. The vocal folds keep on vibrating as it is a voiced sound.

For [ǰ] (voiced palatal affricate) the tongue is raised towards the palate and it closes the pulmonic air. The release of the tongue is done in such a way that the air passing through the oral cavity after the release of this stop, creates a fricative sound while the vocal folds keep on vibrating.

It was decided to test the speech of three speakers of Tamil who belong to three different places. Hence, the authors themselves were used as the subjects, and the investigation was carried out.

Subject 1 : G. Balasubramaniam - Tanjore dialect.
Subject 2 : A. Nallaswamy - Trichy dialect.
Subject 3 : Saroja Ramakrishnan - Kerala dialect.

The utterances were examined on the articulatory principles and also on the broad-hand spectrograms of 80 Hz to 8000 Hz range. For want of time, the data was limited to only ten utterances which included native words as well as borrowed words. The data were pronounced only once (single token) and no carrier sentences were used. The following utterances were used for the analysis.

/itu/	'this'	/putu/	'new'
/matu/	'wine'	/ka:yitã/	'paper'
/poṭi/	'powder'	/maṭi/	'lap'
/ko:ṭi/	'corner'	/paṭi/	'to learn'
/me:čɛ/	'table'	/pu:čɛ/	'worship'

Spectrographic Analysis

All the sounds under analysis are voiced and thus all have got the voice bar.

The hub position decides the point of articulation.

In Table 1 the average hub position for [đ] is between 1267 Hz and 1900 Hz. The variations are due to the preceding and the following vowels. From the hub position [đ] is identified as a dental sound.

The average hub position for [ṛ] lies between 1467 Hz and

2066 Hz and the variations are due to the vowels on either side. The readings tell us that this sound is produced in the front of the mouth.

For [ǰ] the hub positions are relatively low between 1500 Hz and 1533 Hz, compared to [đ] and [ṛ]. Hence we conclude that [ǰ] is produced at the back of the mouth.

Table 2 shows the duration of the intervocalic consonants. The average duration of [đ] is between 40 m/secs. and 55 m/secs. and of [ṛ] is between 33 m/secs. and 43 m/secs. The average duration of [ṛ] is less when compared to [đ] and thus [ṛ] has the possibility of being a flap. Duration of [ǰ] is from 55 m/secs. to 57 m/secs. It has the longest average duration among the three. It may be said that it has the stop properties and the fricative properties, which might have been responsible for its longer duration than the other two.

Table 3 gives the fact about the spike fills. They are important to identify a stop consonant. Spikes showed up only for [đ] and [ǰ] but not for [ṛ]. The spectrogram for /matu/ of Subject 1 did not show any spike fills and the spectrogram for /ka:yitam/ of Subject 2 also did not show any spike fills. However the voiced stops do not always show the spike fills, because plosion of voiced stops will be softer than that of the voiceless stops. The duration of the vowel onset time ranges from 10 m/secs. and 20 m/secs. in all the three subjects. This gives a clue to identify the stop quality of consonant.

There is no fricative noise for [đ]. Since the spike fills are very limited and thin the stop could be a complete stop. So it is reasonable to come to the conclusion that [đ] is not a fricative but a weak stop or a lax stop.

Table 3 also makes it clear that [ṛ] does not have any stop quality and it is a flap, as identified by articulatory phonetics. There is a spike fill for [ǰ] in all the spectrograms followed by the random noise of a fricative. So [ǰ] is an affricate.

Thus it is concluded that the intervocalic /t/, /ṭ/ and /č/ are identified respectively as:

(i) Intervocalic [đ] which is not a fricative but a lax voiced stop, and which may be symbolised as [đ].

(ii) Intervocalic [ṛ] which is a voiced retroflex flap of very short duration.

(iii) Intervocalic [ǰ] which is a voiced palatal affricate with a longer duration than any of the other two sounds noted above.

The present brief acoustic study modifies the conventional phonetic description (vide, the first paragraph of this paper) of intervocalic /t/ while it confirms the conventional description in case of intervocalic /ṭ/ and /č/. In all the three concrete characteristics, about the hub position, duration and spike fill, have been established, though based on a limited data.

It should be confessed here that the study has obvious limitations, though suggestive. The characteristics of the three dialects of Tamil, represented by the three speakers here, have not shown up in the limited data except that /ka:yitam/ (Trichy and Kerala dialects) has a variation as /ka:yitã/ in Tanjore dialect (vide Fig.1).

Table 1 : Hub Position of F_2 in Hz

Words	Subject 1	Subject 2	Subject 3	Average
/itu/	1400	1600	1500	1500
/matu/	1400	1600	1400	1467
/putu/	1300	1200	1300	1267
/ka:yitã/	1900	1900	1900	1900
/poṭi/	1400	1600	1400	1467
/ko:ṭi/	1400	1600	1500	1500
/maṭi/	1800	1700	2100	1866
/paṭi/	1900	2000	2300	2066
/me:čɛ/	1400	1600	1600	1533
/pu:čɛ/	1300	1900	1300	1500

Table 2 : Duration of Medial /t, ṭ, č/

Words	Subject 1	Subject 2	Subject 3	Average
/itu/	45	40	80	55
/matu/	40	50	75	55
/putu/	40	45	65	50
/ka:yitã/	40	40	40	40
/poṭi/	30	30	40	33
/ko:ṭi/	40	30	40	37
/maṭi/	30	40	50	40
/paṭi/	40	40	50	43
/me:čɛ/	45	70	50	55
/pu:čɛ/	50	70	50	57

Table 3 : Spike Fill

Words	Subject 1		Subject 2		Subject 3	
	Height in Hz	VOT in m/secs.	Height in Hz	VOT in m/secs.	Height in Hz	VOT in m/secs.
/itu/	4800 to 7000	10	3000 to 6700	20	300 to 5200	20
/matu/	--	--	500 to 5400	20	300 to 5600	10
/patu/	4500 to 8000	10	500 to 4200	20	2800 to 5600	10
/ka:yitã/	--	10	--	--	300 to 6900	15
/poṭi/	--	--	--	--	--	--
/ko:ṭi/	--	--	--	--	--	--
/maṭi/	--	--	--	--	--	--
/paṭi/	--	--	--	--	--	--
/me:čɛ/	4500 to 7000	10	4300 to 7800	20	300 to 6700	20
/pu:čɛ/	5000 to 5900	10	3600 to 8000	20	300 to 7100	15

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MARATHI AFFRICATES : A SPECTROGRAPHIC STUDY OF DURATION AND INTENSITY

P. V. Pande

0.1. Introduction

Marathi is one of the major languages of India spoken by 7,49,51,207 speakers spread all over the country (Census of India, 1971). It has many social and regional varieties such as Standard Marathi, Nagapuri, Varhadi, Koshti, Kunbi, etc. (Aparna Jha, 1977). The present paper is based on the data drawn from the speech of the author who speaks the Nagpuri variety of Marathi as spoken by the educated people.

The data required for this study were carefully chosen and recorded by the author in the Phonetics Laboratory of the CIIL under sound proof conditions.

As this study is based on the speech of only one speaker, it may be regarded as a sample study. A fuller study needs be made in this regard.

For the purpose of this paper the genuineness of the articulatory description of these affricates by the Marathi Linguists (e.g., Kelkar, 1958) is taken for granted.

Marathi has eight affricates in its inventory of phonemes (Aparna Jha, 1977). They include voiced and voiceless varieties and aspirated and unaspirated series. They are as follows:

	Alveolar		Palatal	
	Voiceless	Voiced	Voiceless	Voiced
Unaspirated	c	j	č	ǰ
Aspirated	ch	jh	čh	ǰh

An affricate is described as a stop released with a close transition into a homorganic fricative (Catford, 1977).

The Marathi affricates /c/, /ch/, /j/ and /jh/ are pronounced with apex and blade of the tongue making contact with the alveolar and post-alveolar region and the closure is released with some delay which causes a hiss following the plosion.

/č/, /čh/, /ǰ/ and /ǰh/ are pronounced with front of the tongue making contact with the post-alveolar and pre-palatal region and the closure is released with some delay which causes a hiss following the plosion.

The distribution of these affricates is as follows:

(i) /c, j, č, čh, ǰ and ǰh/ occur in the initial, medial and final positions; whereas

(ii) /jh/ occurs only initially and medially; and

(iii) /ch/ occurs only medially.

1.0. Purpose of This Study

The purpose of this study is to find out, with the spectrographic evidence, the duration of the affricates, their closure stage, fricative stage and aspiration stage as well as to estimate the intensity of the fricative release of them.

1.1. Instrument and the Data

For this study a word list comprising of 59 Marathi words, containing affricates in different positions and environments was prepared. Maximum care was taken to maintain the environment constant and thus there would be no variation in impact due to environment, on the sounds under study. The words chosen are mostly monosyllabic, but a few are disyllabic.

1.2. Word List

cər	'to graze'	car	'to feed'
cor	'thief'	cuna	'lime'
bhaca	'nephew'	pac	'five'
kəccə	'raw'	ǰar	'paramour'
ǰit	'victory'	bhaǰi	'vegetable'
bhaǰa	'vegetables'	ǰun	'June'
jal	'(you) will go (pl.)	ju	'yoke'
		čəkki	'flour mill'
ǰhu	'zoo'	ǰuṭ	'jute'
čhini	'drilling pin'		
ənuǰ	'son'	majha	'mine, my (masc.)'
səti	'devoted woman'	jər	'if'
jar	'jowari'	jor	'force'
juna	'old'	bhaja	'parch'
paj	'to make to drink'	vəcchə	'calf'
šap	'curse'	šit	'a grain of food'
bhaši	'speaker of language'	bhaša	'language'
jəḍ	'heavy'	jhal	'bamboo cover of basket'
joḍa	'to join'	čhakki	'a 'six' of playing cards'
ǰija	'sister's husband'	ǰhuṭ	'falsehood'

əṅkuš	'control'	maǰi	'former, ex-'
sədi	'century'	sər	'teacher'
sar	'to keep away'	sor	'loud noise'
suna	'vacant'	bhasa	'nephew'
pas	'successful'	čar	'four'
čit	'floored (in wrestling)	bhači	'niece'
		jun	'old'
bhača	'nieces'	ǰu	'lice'
ǰhəḍ	'continuous drizzle of rain'	jhoḍa	'to thrash'
čini	'a Chinese'	ǰhija	'(you) exert (pl.)'
kuč	'breasts'	maja	'(you) become arrogant'
maǰhǐ	'my, mine (fem.)'		

The word list was recorded on the professional type tape-recorder in the Phonetics Laboratory of CIIL, and the tape was used to prepare the broad-band spectrograms having the frequency range from 80 Hz to 8000 Hz on the spectrograph, 6061B, manufactured by Kay Elemetrics Co., U.S.A.

1.3. Procedure

The spectrograms were measured for the total duration of the affricates in the initial, medial and final positions. The duration of the stop portion, the release or the fricative portion and the aspiration portion were measured in milliseconds. The energy concentration of the fricative noise was determined visually in terms of relative darkness. The ranges of frequency, where the energry was concentrated with varying degrees of darkness, were identified. For this purpose the terms 'dark', 'less dark' and 'very dark' have been used. A specially designed scale prepared by the CIIL was used for measuring the duration and frequency.

1.4. Results

Table 1 : Duration of Unaspirated Affricates (in m/secs.)

		Affricate			
		/c/	/j/	/č/	/ǰ/
No. of tokens		11	15	7	9
Initial:	Stop	--	64	--	48
	Fricative	80	60	70	60
	Total	80	124	70	108
Medial :	Stop	50	35	65	46
	Fricative	60	75	75	46
	Total	110	110	140	92
Final :	Stop	60	90	90	50
	Fricative	90	160	90	60
	Total	150	250	180	110

Table 2 : Duration of Aspirated Affricates (in m/secs.)

	Affricate			
	/ch/	/jh/	/čh/	/ǰh/
No. of tokens	1	5	2	3
Initial:				
Stop stage	--	52.5	--	45
Fricative stage	--	95	110	95
Aspiration stage	--	47.5	--	20
Total	--	126	110	160
Medial:				
Stop stage	100	70	--	30
Fricative stage	170	30	--	50
Aspiration stage	20	--	--	20
Total	290	100	--	100

Table 3 : Difference of Duration (in m/secs.) Between Voiceless and Voiced Unaspirated and Aspirated Affricates

Affricate	Initial	Medial	Final
/c/	-64	-55	-100
/j/	+64	+65	+100
/č/	-38	+48	+70
/ǰ/	+38	-48	-70
/ch/	--	+190	--
/jh/	--	-190	--
/čh/	-50	--	--
/ǰh/	+50	--	--

Table 4 : Range of Relative Intensity (in K Hz) of Fricative Noise in Affricates

Affricate	Total Range	Relative Intensity		
		Dark	Very Dark	Less Dark
/c/	2.6 to 8.0	4.6 to 5.9	--	2.6 to 4.6 5.9 to 8.0
/j/	2.7 to 8.0	3.8 to 6.6	--	2.7 to 3.8 6.6 to 8.0
				2.8 to 3.3
/č/	2.8 to 6.8	3.3 to 4.3	4.3 to 6.0	6.3 to 6.8
/ǰ/	2.6 to 7.1	2.6 to 7.1	--	--
/ch/	3.25 to 8.0	--	3.25 to 8.0	--
/jh/	2.4 to 7.2	2.4 to 7.2	--	--
/čh/	1.8 to 6.6	1.8 to 3.7	3.7 to 6.0	6.0 to 6.6
/ǰh/	1.8 to 7.6	2.5 to 7.6	--	1.8 to 2.5

1.5. Observations

Following observations are made from the study of the spectrograms regarding the duration and intensity.

Duration:

From Table 1 it can be seen that /c/ is shorter than /j/ in all occurrences. The difference between the two is 5 ms. and 100 ms. in medial and final positions respectively. /c/ is shorter than /j/ by 50 ms. and 70 ms. in the medial and final positions respectively. It is also evident that /c/ and /j/ have shorter duration in the medial position than in the final position.

In the case of aspirated affricates (Tables 2 and 3) /jh/ is shorter than /ch/ by 190 ms.

As far as the short and long affricates are concerned, the latter is longer than the former by 28 ms., the ratio being 1 : 1.22.

The duration of /jh/ is longer than /ǰh/ by 34 ms. in the initial position whereas /jh/ and /ǰh/ have the same duration of 100 ms. in the medial position.

Duration of Stop Stage:

Duration of the closure for the affricates in the initial position rnages from 48 ms. to 64 ms., in medial position from 35 ms. to 65 ms. and in final position from 50 ms. to 90 ms.

In the aspirated affricates it varies from 44 ms. to 45 ms. (Table 2).

Duration of Release Stage:

In the case of unaspirated affricates the duration of release varies from 60 ms. to 80 ms. in the initial position, from 46 ms. to 75 ms. in medial position and from 50 ms. to 90 ms. in the final.

The duration of the release of the aspirated affricate /jh/ is less than /ǰh/ by 13 ms. in the initial position and by 20 ms. in the medial position.

Duration of Aspiration Stage:

The aspiration stage of the affricates follows the release (fricative) stage on the spectra. It could be measured in 8 tokesn out of the total 11 tokens under study. In the case of the remaining three it was wellnigh impossible to do so. From Table 2, it can be seen that this duration of aspiration in /ch/ and /jh/ in the initial position is 20 ms. each.

Relative Intensity of Fricative Noise:

The relative intensity range for all the affricates is shown in Table 4 in terms of **Dark, Very Dark** and **Less Dark**, which corresponds to the respective degree of energy.

The range of this fricative noise concentration /čh/ and /ǰh/ can be seen on the spectrograms from 1800 Hz extending upwards, whereas for /ch/ it appears from 3250 Hz to 8000 Hz and above. The rest of the affricates also show the random noise spread upwards from 2400 to 2800 Hz. The maximum concentration of intensity can be seen for /č/, /ch/ and /čh/ in Table 4 representing the greater intensity shown for these affricates.

Conclusion

1. From the foregoing observations it can be concluded that the voiced affricates are longer in duration than their voiceless counterpart.

2. Aspirated affricates are found to be longer in duration than the unaspirated ones, as expected.

3. The alveolar affricates are seen to have longer duration than the palatal ones, the difference between /c/ and /č/ being 10 ms. in the initial position, 30 ms. in the medial and 30 ms. in the final position. /j/ is longer than /ǰ/ by 16 ms., 23 ms. and 140 ms. in initial, medial and final positions respectively.

4. The frequency range of the intensity distribution has correlation with the place of articulation. The alveolar affricates are seen to have longer range than the palatal ones (Table 4). /c/ has the range from 2600 Hz to 8000 Hz, whereas /č/ has the range from 2800 Hz to 6800 Hz. Similarly, /j/ has the range from 2700 Hz to 8000 Hz as compared with the range of /ǰ/ which is from 2600 Hz to 7100 Hz. The energy correlation with respect to the manner of articulation also shows that the voiceless affricates have longer range of frequencies than the voiced one (Table 4). The unaspirated affricates show comparatively shorter range than the aspirated ones.

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SPECTROGRAPHIC STUDY OF VOICELESS URDU FRICATIVES

A. G. Khan
N. A. Malik

1. Introduction

Standard Urdu has eight fricatives /f, s, š, x, h, z, ž, ɣ/ (Hassan and Koul). Urdu fricatives display marked individualistic tendencies. There is a prominent asymmetry in relation between voiceless and voiced fricative in that there are five voiceless /f, s, š, x, h/, but only three voiced fricatives /z, ž, ɣ/. The places of articulation of these fricatives are as follows:

Labio-dental		Alveolar		Palato-alveolar		Velar		Glottal	
Vl.	Vd.	Vl.	Vd.	Vl.	Vd.	Vl.	Vd.	Vl.	Vd.
f	-	s	z	š	ž	x	ɣ	h	-

To the best of our knowledge, no published material about the acoustic properties of Urdu fricatives is available. We therefore proposed to work on 'the spectrographic study of fricatives'. Keeping in view, the limitations of time, only the voiceless fricatives in isolation and in the sets of minimal pairs of words are investigated.

2. Method, Material and Procedure

A list of isolated words with voiceless fricatives occurring in word initial, medial and final positions was prepared. Sufficient care was taken to keep the environment identical, as for as possible. The authors (Khan and Malik, hereafter S_1 and S_2

respectively) who represent standard Urdu, recorded the words listed below. The recording was done in the sound proof studio of the Phonetics Laboratory of CIIL. The broad-band spectrograms of the words were taken on Spectrograph, type 6061B manufactured by Kay Elemetrics, U.S.A.

3. List of Words

/fam/	'coloured'	/nəša/	'intoxication'
/nəfa/	'beneficial, profitable'	/kaš/	'puff, force of throwing'
/saf/	'clean, clear'	/xal/	'mole'
/sal/	'year'	/taxir/	'delay'
/rəsi:d/	'receipt, acknowledgement'	/šax/	'branch'
/sas/	'mother-in-law'	/hal/	'hall'
/šam/	'evening'	/kəhə/	'said'

4. Analysis

The following analysis of the voiceless Urdu fricatives includes - (i) The distribution of random noise associated with the voiceless fricatives at various places of articulation; and (ii) The frequency level at which the intensity of each fricative would be concentrated. The duration of the fricatives are as follows:

Table 1 : Duration of Voiceless Fricatives (in m/secs.)

Segment	Initial			Medial			Final		
	S_1	S_2	Average	S_1	S_2	Average	S_1	S_2	Average
f	100	110	105	80	90	95	200	-	200
s	130	140	135	110	110	110	200	200	200
š	110	130	120	100	110	105	220	200	200
x	120	140	130	100	110	105	130	-	130
h	90	100	95	70	-	70	-	-	-

[**Note:** A dash (-) indicates non-availability of data].

5. Measurement of Duration

As it is evident from Table 1, the durations of these fricatives, in the speech of S_1 and S_2 vary to a very limited extent. The speech of S_1 and S_2 vary from the average by 0 to 10 m/secs. which is a negligible margin.

6. Observations Based on the Analysis

(i) The duration of fricatives in the final position is longer than in their initial or medial positions.

(ii) It appears from the limited data that all the voiceless fricatives are comparatively short in medial position than in the other positions.

(iii) Among the fricatives /h/ is the shortest in duration irrespective of its position in the word.

(iv) The order of fricatives arranged in the increasing order of duration is: /h/ < /f/ < /š/ < /x/ < /s/, except in final position.

(v) In the final position /h/ has no occurrence in the data and /x/ has lesser duration than /f/, /s/ and /š/ which have equal duration.

(vi) On the average the fricatives have a minimum duration of 70 m/secs. and a maximum duration of 200 m/secs.

It must be noted that no general validity is claimed for the results, as the data under investigation are very much restricted. However, the results are symptomatic of the realities in the language.

7. Frequency Range of Fricatives

According to Potter-Kopp-Green "the voiceless fricatives are produced by frictional modulation". The acoustic correlate of frictional modulation is the distribution of random noise on spectrograms, the appearance of random noise and its distribution over the frequency range has been tabulated below:

Table 2 : Frequency Range of Fricatives (in Hz)

			Segment				
			f	s	š	x	h
Initial							
	Low :	S_1	1100	5000	1400	500	800
		S_2	1400	3500	1500	500	900
		Average	1250	4250	1450	500	850
	High :	S_1	5800	7000	6100	6000	-
		S_2	6000	7100	6500	5500	5600
		Average	5900	7050	6300	6250	5600
Medial							
	Low :	S_1	1400	2000	1500	500	500
		S_2	1400	3500	1500	500	-
		Average	1400	2750	1500	500	500
	High :	S_1	5600	7000	6300	6500	-
		S_2	6000	7500	6500	6000	3900
		Average	5800	7250	6400	6250	3900
Final							
	Low :	S_1	1600	5000	1500	500	-
		S_2	-	4000	1700	-	-
		Average	1600	4500	1600	500	-
	High :	S_1	5600	7000	6500	6500	-
		S_2	-	8000	7000	-	-
		Average	5600	7500	6750	6500	-

[**Note:** Dash (-) indicates non-availability of the data].

8. Observations

On the basis of the tabulated figures of frequency distribution, the following observations are made on the limited data.

1) /f/ : Lowest level of average frequency at which the acoustic energy of noise appears on the spectrogram is between 1250 and 1600 Hz. Upper limit of frequency is between 5600 and 5900 Hz.

2) /s/ : Lowest level of average frequency is between 2750 and 4500 Hz. Upper limit is between 7050 and 7500 Hz.

3) /š/ : Lowest level of average frequency at which energy is concentrated on the spectrogram is between 1450 and 1600 Hz, and the upper limit ranges from 6300 to 6750 Hz.

4) /x/ : It has the lowest level of average frequency at 500 Hz, and the upper limit ranges from 6250 to 6500 Hz.

5) /h/ : Lowest level of average frequency is between 500 and 850 Hz, whereas the upper limit ranges from 3900 to 5600 Hz.

Conclusion

Among the fricatives /h/ the shortest distance between average lowest level and highest level. The fricatives /f/, /x/ and /h/ have a low frequency random noise when compared with /s/ and /š/, which have high frequency random noise. In addition, /h/ is characterised by the weaker formant bars of the following /a/ vowel and the weaker random noise than the other fricatives.

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SPECTROGRAPHIC ANALYSIS OF LIQUIDS IN KANNADA

H. M. Maheshwaraiah

Introduction

Kannada language has three liquid phonemes: /r/, /l/ and /ḷ/; /r/ and /l/ occur word initially and medially whereas /ḷ/ occurs only word medially. In the intervocalic position all these liquids occur in gemination.

For the purpose of the present study I have taken both single (short) and geminated (long) occurrences spoken by the author representing the Shimoga dialect of Kannada. Since the material is drawn from one speaker it may be considered as a symptomatic study of the liquids in Kannada.

Data

/ri:ti/	'manner'	/mora/	'winnowing pan'
/ra:ga/	'music'	/hore/	'bundle'
/ru:pa/	'beauty'	/iri/	'stab'
/roṭṭu/	'cardboard'	/barri/	'come'
/riṇa/	'obligation'	/ku:ri/	'sit, please!'
/liṅga/	'Lord Linga'	/kaḷe/	'dirt'
/lo:ḷe/	'sticky substance'	/ka:lu/	'leg'
/luṅgi/	'dhoti'	/ili/	'mouse'
/iḷi/	'to get down'	/kali/	'learn'
/moḷa/	'measurement' (approx. 18")	/bali/	'sacrifice'
/hoḷe/	'river'	/sala/	'(number of) times'
/baḷḷi/	'creeper'	/me:le/	'above, on'

/eḷḷu/	'gingely'	/ki:li/	'lock'
/kere/	'tank'	/huli/	'tiger'
/ke:ri/	'lane'	/sa:lu/	'row'
/kuru/	'boil'	/ko:lu/	'stick'
/ku:ru/	'sit'	/nu:lu/	'thread'
/sara/	'chain'	/bale/	'net'
/nari/	'fox'	/ha:lu/	'milk'
/na:ri/	'woman'	/a:la/	'banyan tree'
/sa:ru/	'broth, gruel'	/čalo/	'good'
/so:ru/	'leak'	/mola/	'rabbit'
/bi:ru/	'cupboard'	/palli/	'lizard'
/kallu/	'stone'	/hole/	'to sew'
/sallu/	'be suitable'	/be:re/	'separate'

Method

The above data were recorded in a sound-proof studio of the Phonetics Laboratory. The spectrograms of these words were made by using the sound spectrograph 6061B type manufactured by Kay Elemetrics Company, U.S.A. Only wide band spectrograms (80-8000 Hz) were made for the present analysis and the measurements of duration were taken in milliseconds.

Duration of Liquids

Duration figures of the above mentioned liquids are given in Tables 1 and 2.

As shown in the Table 1, the initial short trill /r/ is 6 ms longer than the short intervocalic trill /r/, the ratio being 1 : 1.2. Intervocalic short lateral /l/ is 11.3 ms longer than the initial /l/, the ratio being 1 : 1.2.

As shown in the Table 2, the intervocalic long trill (-rr) is

86.7 ms longer than the short trill. The ratio is about 1 : 5.5. The intervocalic long trill occurring after a short vowel has longer duration when compared to the same trill after a long vowel.

Table 1 : Comparison of Initial and Medial Short Liquids in Kannada

Sound	No. of tokens	Duration in m/secs.			
		Minimum	Maximum	Average	Difference
r-	5	20	40	30	6
-r-	15	20	35	24	
l-	4	40	100	66.2	11.3
-l-	16	60	85	77.5	

Table 2 : Comparison of Medial Short and Long Liquids in Kannada

Sound	No. of tokens	Duration in m/secs.			
		Minimum	Maximum	Average	Difference
-r-	15	20	35	24	86.7
-rr-	2	100	160	130	
-l-	16	60	85	77.5	107.5
-ll-	3	165	200	185	
-ḷ-	4	30	60	43.3	134.2
-ḷḷ-	4	150	190	177.5	

The intervocalic long lateral has 107.5 ms longer duration when compared with the intervocalic short lateral. The ratio is about 1 : 2.3. The intervocalic short retroflex lateral has 134.2 ms longer duration when compared to the corresponding short retroflex lateral. The ratio is about 1 : 4.1. This shows that ratio between short and long trill is greater than the ratio of short and long lateral. Within the laterals, the ratio between short and long retroflex is again somewhat greater than the ratio of non-retroflex lateral. Thus there is a large variation between the duration of /r/ and /l/ and also between short and long liquids depending on their type of articulation.

The short and long liquids are arranged in the decreasing order of duration: rr ⊳ ll ⊳ ḷḷ ⊳ l ⊳ ḷ ⊳ r.

Formants of Vowels Preceding and Following the Liquids

The Tables 3 and 4 show the formants of the vowels occurring before and after the medial liquids in Kannada. The F_1 and F_2 figures of the vowels have been arrived at by taking the average of all the occurrences of the vowel in a particular environment. For the present analysis only the F_1 and F_2 figures are taken and the difference between F_2 and F_1 are also given in the 'diff.' in the Tables. The blank indicates the non-availability of data at the moment.

Table 3 : Formant Frequencies of Vowels Preceding the Liquids

Vowels	Before /r/			Before /l/			Before /ḷ/		
	F_1	F_2	Diff.	F_1	F_2	Diff.	F_1	F_2	Diff.
i	250	2050	1800	275	2100	1825	300	2000	1700
e	535	1900	1365	600	1900	1300	500	1500	1000
a	670	1260	590	670	1250	580	635	1300	665
o	460	935	400	535	1120	585	535	1080	445
u	375	800	425	400	865	465	-	-	-

Table 4 : Formant Frequencies of Vowels Following the Liquids

Vowels	After /r/			After /l/			After /ḷ/		
	F_1	F_2	Diff.	F_1	F_2	Diff.	F_1	F_2	Diff.
i	290	2060	1770	320	2060	1740	325	2100	1775
e	535	1885	1350	575	1800	1225	525	1790	1165
a	750	1275	525	700	1300	600	800	1300	500
o	500	1100	600	500	1000	500	-	-	-
u	345	885	540	400	950	550	350	1000	650

It may be seen from the Tables 3 and 4 that all the vowels except /o/ have fairly uniform F_1 and F_2 before /r/, /l/ and /ḷ/. /o/ has lower F_1 and F_2 figures before /r/. This indicates that /o/ before /r/ has a tendency to become /ɔ/. There was one instance of /a/ in /palli/ which has 500 (F_1) and 800 (F_2) as against the 670 (F_1) and 1250 (F_2) average of the other occurrences. The word was transcribed as /pʌlli/, according to the formant frequencies, and taken out of the present discussion. The long vowels except /a/ were higher in quality whereas long /a/ was lower in quality when compared with their short counterparts.

There is a variation in the shape of the formants of the following vowel of /r/ and /l/. But there is no variation in the shape of the formants of the preceding vowel of /r/ and /l/. This means that the distinction of /r/ and /l/ is shown by the following vowel rather than the preceding one.

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A SPECTROGRAPHIC STUDY OF /r/ AND /R/ IN MALAYALAM

R. Yamuna

There is a controversy among linguists about the manner of articulation of /r/ and /R/ in Malayalam. Most of the descriptive grammarians of Malayalam consider these two as voiced alveolar flap and voiceless alveolar stop respectively. Probodhachandran Nayar (1979 : 17) considers these two as flap, viz., /r/ as a voiced palatalized dentialveolar flap and /R/ as a voiced non-palatalized alveolar flap. Occassionally the articulation of /R/ involves more than one tap of the tongue tip against the alveolum. /r/ is non-final in both native and marginal forms[1].

Gundert has noted the merger of [r̲] (trill) and [r] (flap) but he has not shown the specific contexts of each. According to Matthan /r/ should be pronounced as /r̲/ in clusters and in the pronunciation of Sanskrit vocalic /ṛ/. But before /y/, /s/ and /š/ and after sonants, /r/ has flapped articulation (Matthan, 1969 : 41).

The purpose of this study is to find out the acoustic clues of /r/ and /R/ in Malayalam. The data is taken from my own dialect, and it is very limited. The spectrograms were made in wide band with frequency range from 80 Hz to 8000 Hz. The methods adopted to find out the acoustic clues are the following: (i) to find out the comparative length of /r/ and /R/, and (ii) to find out the formant frequencies at the offset of the preceding vowel and at the onset of the following vowel. The data used are given below:

1.	/maravi/	'a wooden vessel for keeping salt'
	/maRavi/	'forgetfulness'
2.	/murukku/	'a tropical tree'
	/muRukku/	'a kind of eatable'
3.	/čiri/	'laugh'
	/čiRi/	'lip'
4.	/karuttu/	'courage'
	/kaRuttu/	'became dark'
5.	/eriññu/	'burnt'
	/eRiññu/	'threw'
6.	/ariññu/	'eat'
	/aRiññu/	'knew'
7.	/muričču/	'roasted in oil'
	/muRičču/	'cut into two pieces/
8.	/čoriññu/	'poured out'
	/čoRiññu/	'scratched'
9.	/toran̲n̲u/	'pierced'
	/toRan̲n̲/	'opened'
10.	/n̲eran̲n̲u/	'became level'
	/n̲Runnu/	'filled'
11.	/aaru/	'who'
	/aaRu/	'river'
12.	/uuri/	'to take out'
	/uuRi/	'to spring'

Measurement of Duration and Formant Frequencies

The duration of /r/ and /R/ turns out to be three-fold on the basis of the measurements of the spectrograms. /R/ also appears with only one tap like /r/. But in three pairs (i.e., Sl.Nos.2, 4 and 12) out of 12 pairs /R/ appears with more taps than one, indicating thereby that in those instances /R/ is a Trill.

Table 1 : Duration of /r/ and /R/ (Single Tap and Trill)

	Number of tokens	Duration in m/secs.		
		Minimum	Maximum	Average
r	12	15	35	25.23
R (single tap)	9	10	20	16.1
R (trill)	3	45	50	46.66

It may be seen from the above Table that /r/ has intermediate duration whereas /R/ shows marked distinction between single tap and trill. The arrangement of the three varieties in terms of increasing duration would be as follows:

/R/ (single tap) < /r/ < /R/ (trill)

It may be concluded that in the conventional writing system the graph used for /R/ represents both single tap and trill.

Formant Frequencies

The formant frequencies of the preceding and following vowels of /r/ and /R/ (single tap and trill) were measured and the average frequencies of the vowels are tabulated below:

Table 2 : Formant Frequencies of Preceding and Following Vowles of /r/ and /R/ (Blank indicates the non-availability of data at the moment)

	Preceding /r/		Following /r/		Preceding /R/ (one tap)		Following /R/ (one tap)		Preceding /R/ (trill)		Following /R/ (trill)	
	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2	F_1	F_2
i	350	2550	350	2430	300	2000	370	2410			240	2500
e	550	2350			550	2050						
a	766	1633	666	1683	733	1583	666	1550	750	1500		
o	500	1200			600	1250						
u	400	900	400	1000	350	700	600	1000	300	825	375	825

There are no perceivable clues on the basis of the formant frequencies to distinguish between the three varieties of the sound. However, the formants showed up with very interesting shapes of the formants. The following illustrations would give an idea about the shapes of formants.

FOOTNOTES

1. Phonetically, [r] alveolar voiced flap with a slight trilling occurs initially and intervocalically.
   e.g., /peeru/ [pe:ru] 'name'
   [r̲] alveolar trill with less tappings than that of [R] occurs elsewhere.
   e.g., vaarpu [va:rpɯ] 'cauldron'
   avar [ʌvəᵛr̲] 'they'

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THE PROBLEM OF ASPIRATION IN HINDI AND GUJARATI

K. Rahman
V. P. Jain
P. J. Patel

Gujarati "Hindi and other Indo-Aryan languages are unique among the world's languages in possessing contrast between aspirated and unaspirated stops in both the voiceless and voiced series, i.e., [p] Vs. [ph] and [b] Vs. [bh][1]. The exact physical correlates of the aspirates vis-a-vis the non-aspirates have been a subject of considerable interest to linguists for over 2000 years" (Ohala, M., 1983, Appendix, p.155).

The aim of the paper is to discuss and probe into the nature of aspiration.

In the present paper we will make an attempt to show that the western linguists have said about aspiration. Due to various limitations, we will not be able to examine all the views of different western scholars. It is also not possible to look into factors like air-pressure/air flow, glottis opening/closing and the "multiple, physiological and acoustic characteristics" (Fisher Jørgensen, 1968). Our scope is thus restricted to look for the "brief period of voicelessness during and immediately after the release of an articulatory stricture" (Ladefoged, 1971) and also for what happens during the segments having 'murmur' or 'breathy voice' (Ladefoged, 1975). The technique that was chosen was, therefore, sound-spectrography. Again due to the limited time available we could not but choose ourselves as informants and limit ourselves to a list of twenty words only that showed the contrast by voicing and aspiration in the initial position only.

Let us now have a look at what the western linguists have said about aspiration. Henry Sweet (1906 : 58) perceives aspiration as a "puff of breath" released with "audible explosion". Daniel Jones (1957 : 138-152) describes aspiration as a 'short breathed sound'. He also says that "it is a noticeable puff of breath or aspiration (i.e., a slight h), heard after the release of a stop", and before the beginning of the vowel". Fant (1960 : 19) looks at aspiration as "an h-like sound produced with greater articulatory opening". According to Lisker and Abramson (1964) the voice onset time is the primary characteristic feature of aspiration. Fischer-Jørgensen (1968) says that aspiration[2] has to be studied in terms of multiple physiological characteristics apart from the acoustic. Later on she describes aspiration in terms of the voiceless position of the glottis. Kim (1970) says that aspiration implies "glottal opening at the time of release of the oral closure of a stop". Ladefoged (1971) defined aspiration as a "brief period of voicelessness during and immediately after the release of an articulatory stricture". According to him "most languages use only a binary opposition, and no language contrasts more than three possibilities". Later, Ladefoged (1975) describes the fourth category of stops as having 'murmur' or 'breathy voice', that occurs when the vocal cords are only slightly apart; the anterior region vibrates and at the same time a great deal of air passes through the posterior region of the glottis. Catford (1977) acknowledges Ladefoged (1971) by saying that "the use of the term voiced aspirated stop for these sounds" is inadequate in the sense that 'one is using neither the term voiced nor the term aspirated in the same way' as in the description of voiceless aspirated stops such as [p^h, t^h, k^h]. Ladefoged's objection, however, loses much of its validity when one thinks of both voiceless and voiced aspirated sounds as involving delayed onset of normal voicing; the fact is that in such sounds as [b^h] there is whispery voice rather than voicing during the stop and for a certain period after its release. Just as with voiceless aspirated stops there is thus a delay in the onset of normal voice".

Dixit (1979) defines aspiration as glottal frication with or without pulsing while the glottis is narrowly or widely open and the supra-glottal vocal tract is unobstructed.

Chomsky and Hale (1968) claimed that Heightened Sub-glottal Air Pressure (HSAP) was a necessary characteristic of all aspirated consonants, i.e., [b^h] and [p^h], a possible but non-essential characteristic of voiceless unaspirated consonants, i.e., [p], and must necessarily be absent from voiced unaspirated consonants, i.e., [b].

Halle and Stevens (1971) rejected the use of the feature HSAP for aspirates and posited instead the new feature composition [+ spread glottis - Constricted glottis] as being common to the aspirates, the [b^h] being differentiated from [p^h] by means of additional features (p^h = + stiff vocal cords - slack vocal cords and b^h - stiff vocal cords + slack vocal cords).

Manjari Ohala (1983 : 157) writes, "we believe the results in the present paper are useful in showing that the original feature of HSAP was wrong, because although it was adopted by Chomsky and Halle without empirical evidence, so it was discarded by Halle and Stevens also without any evidence. M. Ohala (1979) reviewed evidence which suggested that although the aspiration do have a spread glottis, as suggested by Halle and Stevens, this feature is not unique to them since it is also shared by voiceless unaspirated stops. Original experimental investigations were also reported which showed that as for the feature 'Vocal Cord Tension', only a single binary feature is needed to differentiate the voiced aspirates from other stop types".

According to Brosnahan and Malmberg (1970), "if the air-stream pressure is low, and/or the next closure of the tract is simultaneous with the supra-glottal release, the escape of air may be nil or negligible. On the other hand, if the pressure is high, and the next closure delayed, it may be very considerable, and clearly audible as a sound resembling [h] after a voiceless plosive and [ɦ] after a voiced one. In these cases the plosive is said to be aspirated, or to have an aspirated release" (cf. the views of the Sanskrit grammarians).

It can, therefore, be said that aspiration has been defined with varying degrees of precision. Some have relied only on the resultant auditory/acoustic aspects of aspiration, some others have concentrated on the concomitant air pressure/flow and some others still, on glottal constriction and glottal opening. But no one seems to have captured aspiration to describe it in very precise terms. With this kind of an uncertain area in phonetics around, certain linguists have pursued various other problems connected mainly with aspiration.

Kelkar (1958) has even gone to the extent of positing [h] as a semi-vowel in Marathi, and he treats aspirates as clusters of consonant plus [h] (See, Kelkar, 1968). Similarly, Harms (1966 : 603) has argued (with reference to Bengali) 'that the predominance of unaspirated consonants in the lexicon would make the cluster interpretation more economical and hence better'. Obviously, he is in agreement with Kelkar (1968) who looks at an aspirate as a cluster of consonant and [h]. But Srivastava (1969) and Narang and Becker (1971) have argued otherwise and have preferred, like the Sanskrit grammarians, to recognize an aspirate as a unit. Though Kelkar wrote a rejoinder to Srivastava (1969), we shall not go into it here.

Rajapurohit (1982) has observed on the basis of Oscillographic study, that the noise pattern of [h] in various positions in Kannada and that of aspiration were the same. The durations were also almost the same. But the aspiration affected the duration of the preceding consonant, i.e., it reduced the duration of the preceding consonant.

Let us look into the literature on murmured sounds.

Adenwala (1965) observes that "murmured vocoids are not considered unit phonemes but are analyzed as clusters of clear vowels and [h], of which murmuring would be one of the allophones". In the case of Gujarati, it becomes imperative to examine the inter-relationship between the Aspiration murmuring and [h] in addition to the contrasts between aspiration and the lack of aspiration of consonants and between murmured and clear vowels. The conclusion mentioned below is the one arrived at by Prabodh Pandit (1957) which states that the components of aspiration and murmur are the allophones of /h/. In Gujarati, /h/ occurs initially and intervocally. Murmuring occurs simultaneously with vowels and aspiration occurs simultaneously with consonants. Thus they are in complementary distribution. According to Pandit, the consonant [h] occurs as the aspirated release of voiced stops: [la:bh] benefit. In such cases the [h] may disappear and instead the preceding vowel is murmured. There is a free alternation between [la:bh] and [la̲:b], (where [a̲:] is a murmured vowel).

The Sanskrit grammarians have used the terms Mahāprāṇa and Alpaprāṇa as the terms for aspirated and unaspirated consonants respectively. The grammarians have taken these technical concepts as external-manners of articulation (Bāhyaprayatna). Bāhyaprayatna means that originally there is no difference in the nature of the air-streams of different sounds, i.e., aspirated or unaspirated sounds, the air-stream is the same, but due to the manner of external vocal apparatus, the sounds change, so the changing factor is the external vocal apparatus, not the internal. Besides, there is a great amount of prāṇa (air-flow) in the articulation of aspirates, while in the unaspirated (alpaprāṇa) it is less. According to them, an aspirate is a combination of the unaspirated consonant and the [h] sound. Pāṇini has referred to [h] sound in his Pratyāhāra-Sūtras, twice. The aim of referring to it twice is to account for the fact that [h] can either be voiced or voiceless, whereas all other fricatives in Sanskrit like sšṣ are voiceless. Thus the voiceless consonant and voiceless [h], because it is the rule of the nature and the morphophonemics of Sanskrit also, that similar sounds go together. There is one sūtra in Aṣṭādhyāyī of Pāṇini - "Tulyāsyaprayatnam savarṇam". It means that the sounds, the place and manner of articulation of which are the same, are savarṇa (similar). The sounds of different nature cannot go together. Even if they are joined, they will always remain different. So the voiceless consonant goes with the voiceless [h] to make an aspirate. In the case of voiced aspirates, voiced [ɦ] or voiceless [h] may be combined with a voiced consonant. Thus the following rule can be formulated.

Voiceless unaspirated consonant + [h] = voiceless aspirate.

$$\text{Voiced unaspirated consonant} + \begin{bmatrix}[\text{h}]\\ [\text{ɦ}]\end{bmatrix} = \text{voiced aspirate.}$$

Findings

On the basis of the spectrographic study, the following observations are recorded.

1. During the aspiration of voiceless sounds, it is observed that the area between the stricture for the stop and the onset of the vowel is marked by -

   (a) no voice bars
   (b) formants of devoiced vowel
   (c) random noise

2. During the aspiration of voiced sounds,it is observed that the area between the stricture for the stop and the onset of the vowel is marked by -

   (a) Voice bars: sometimes only partially and sometimes total absence of them (see the spectrograms illustrated)
   (b) formants of devoiced vowel
   (c) random noise

On the basis of these findings, it can be stated that aspiration comprises:

(i) devoiced vowel and
(ii) random noise and not devoiced vowel only.

In the case of voiced aspirates, the portion of aspiration is sometimes accompanied by voice and sometimes not. As regards the voiceless vowel, it is very clearly seen that only when the following vowel is [a:], it is present. In the case of [i] and [ɔ] it is absent (See, O'Connor, 1973 : 160-161, Plate 6).

With respect to aspiration in Gujarati it is seen that -

(i) in voiceless aspirated sounds no voice bars are seen, but there are vowel formants (faintness shows devoicing) with noise, and

(ii) in voiced sounds, voice bars are generally seen in the aspirated area along with formants for the devoiced vowel[3].

FOOTNOTES

1. Only bilabial series of stops is mentioned here, though it applies as well to the stops at other points of articulation.

2. Eli Fischer Jørgensen : 'Aspiration in French and Danish'.

3. In Gujarati [jha:l] voicebar is seen only in the beginning of aspiration, which is followed by no voicebars but noise above 3000 Hz. But in [d^{h}ol] and [b^{h}ar], [d] and [b] do show voicebars but no vowel formants are seen. Very little noise is seen.

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A STUDY OF /h/ AND ASPIRATION IN HINDI

Shobha Goel

1. Introduction

The present study is an acoustic investigation of the nature of /h/ and the aspiration of the final aspirated plosives in Hindi. It is generally assumed that /h/ and the aspiration part of the aspirates have common characteristics on the basis of which they are grouped together; but there are some differences on the basis of which they are separated from one another. The present study tries to explain whether the two belong to the same category or they form two distinct entities in Hindi.

2. Methodology and Analysis

The following lists of words contain:

(a) The eight aspirated plosives, both voiced and voiceless in the final position.

saph	'clean'	labh	'profit'
sath	'together'	sadh	'longing'
saṭh	'sixty'	ḍhaḍh	'scream'
rakh	'ash'	bagh	'tiger'

(b) Six words showing /h/ in initial, medial and final positions.

Initial		Medial		Final	
hath	'hand'	kaha	'said'	rah	'path'
hɛ	'is'	raha	'lived'	ah	'exclamatory expression'

The data is taken from standard Hindi with one exception, namely,

/ḍhaḍh/[1]. So far as /ph/ (voiceless bilabial aspirated plosive) is concerned, this sound is fast disappearing from standard Hindi and is replaced by /f/, the labio-dental voiceless fricative in almost all contexts. However, for the purpose of the present study, /ph/ has been taken and deliberately pronounced.

The data were recorded by a female informant in the Phonetics Laboratory of the Central Institute of Indian Languages, and wide band spectrograms were taken on Sonagraph 6061B of Kay Elemetrics.

The spectrograms were measured by a scale designed at CIIL, and the results are presented in Tables 1 and 2. Table 1 presents the acoustic properties of /h/ in the initial, medial and final positions. Table 2 presents the duration, spike fill and voicing.

3. Observations

Some of the observations made while analysing the spectrograms may be summarised here.

1) In some cases the noise of /h/ and aspiration starts right from the base line and goes up to 4000c/s.

2) /h/ has more regular pattern than aspiration.

3) Because /h/ has regular patterns /h/ the noise pattern displayed correlates with the formant structure of the adjacent vowel (following vowel in case of initial and medial occurrence and the preceding vowel in case of final one).

4) /h/ is voiceless in the initial and final positions, and weakly voiced in the medial position.

5) /h/ appears to be more like a voiceless vowel on account of its formants and the missing voice bar (which of the vowel is indicated in 3 above).

So far as the aspirates are concerned, following observations were made:

1) Noise is distributed randomly over a wide frequency range.

2) The duration of the aspiration part of the aspirates varies without any clue for generalization. Further exploration might bring in some more observable features.

4. Conclusion

Based on the above discussion, it can be said that /h/ and the aspiration (particularly in the final position) are not the same. We have noticed that in the case of /h/, there is a regularity whereas the aspiration did not show any regularity. This tells upon the difference in the resorance in the oral cavity.

Aspirates contained more random noise. However, as the aspirates have not been analysed in the other positions, it would not be fair to stretch the observation based on the final occurrence, to other positions.

Table 1 : /h/ in Three Positions

Initial :	Average duration in m/secs. ...	100
	Frequency range of noise ...	250 to 4500
	Voicing ± ...	-
Medial :	Average duration in m/secs. ...	100
	Frequency range of noise ...	250 to 4000
	Voicing ± ...	+
Final :	Average duration in m/sec. ...	140
	Frequency range of noise ...	250 to 4500
	Voicing ± ...	-

Table 2 : Aspirates in the Final Position

	Duration in m/secs.			Spike fill range in Hz.	Voicing ±
	Stop	Aspirate	Total		
ph	160	80	240	80-1800	-
bh	160	80	240	80-1850	+
th	130	25	155	300-2300	-
dh	110	40	150	150-2800	+
ṭh	150	60	210	80-3400	-
ḍh	90	100	190	100-3800	+
Kh	150	20	170	700-1300	-
gh	110	30	140	600-1400	+

FOOTNOTES

1. /ḍh/ being not available in the final position in standard Hindi, this word has been taken from a dialect of Hindi spoken in Western part of Madhya Pradesh.

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SUPRASEGMENTALS IN BHOJPURI

R. B. Misra

Introduction

Bhojpuri, the westernmost speech of the Magadhan group of the Indo-Aryan languages in India, is a living vernacular of a large tract of the east Uttar Pradesh, West Bihar and Northeast Madhya Pradesh. In an area of about 50 thousand square miles in the heartland of Northern India, the population of which is more than 60 million, it is a live manifestation of the Magadhan culture.

There are quite a few works on Bhojpuri, by earlier scholars such as Grierson (1903), Uday Narain Tiwari (1960), A.B. Singh (1960), Mahendra Nath Dubey (1966), Shukdev Singh (1968), Kripa Shankar Singh (1973) etc. But most of them have concentrated their attention on some aspect of historical development, morphology, syntax, semantics, regional variations and so on. Even the author's doctoral dissertation at the University of Poona, Deccan College is only a sociolinguistic account of the dialect. The phonetics and phonology of Bhojpuri have been little worked out, and the suprasegmentals the least. The only work worthy of mention is by Vishwanath Prasad (1950).

The present report is an attempt to investigate the suprasegmentals in Bhojpuri, as spoken by the author who is a native speaker of Bhojpuri. The list of words and sentences was carefully drawn-up to bring about the contrasts of the prosodic features. After carefully grading them into a selected check-list, they were recorded in the sound proof studio of the CIIL. The spectrograms were taken in narrow band, with amplitude display.

Stress

The stronger muscular effort both respiratory and articulatory with respect to some syllables as opposed to the others is identified as stress. Such stress is found in isolated Bhojpuri words. The stressed syllable sounds louder (has higher amplitude) and has longer duration; and consequently is more prominent than the unstressed ones.

For example:

córwa	'the thief (derogatory)'	séra	'name of a dog'
corwá	'to hide something'	será	'to get cold'
pə́chuwa	'the west wind'	dékh(ə) lake	'for having seen'
pəchuwá	'to lag behind'	dekh(ə) láke	'after having shown'
		ḍéra	'resistence'
		ḍerá	'be afraid'

It was observed on the spectrograms that the stressed words had higher amplitude and longer duration when compared with their unstressed counter parts.

Juncture

A kind of pause in the intra-sentence chain of speech in order to differentiate one sense group from the other is characteristic of jucture. This is observed in Bhojpuri.

For example:

kəhəna	'order'	bəṛhiai	'will be flooded'
kəhəna	'tell (certainly)'	bəṛhi ai	'will come up/forward'

It was observed on the spectrograms that the utternace with no juncture had higher amplitude on the first syllable, whereas the one with juncture had lesser amplitude on the first syllable.

Nasalization

It is a well attested phonemic feature in Bhojpuri.

kat	'cut'	hə	'is'
kãt	'thorn'	hə̃	'yes'

Spectrographically it was observed that the nasalised and the non-nasalised vowels did not show any change in Fo. (10th harmonic appeared at 1250 Hz in both the cases). The duration was also almost equal. But the amplitude display of the latter half was showing marked difference. Nasalised vowels had higher amplitude there.

Length

From articulatory point of view a double consonant is a long consonant "in the articulation of which the interval of silence between the stop stage and the off-glide stage of the consonant takes considerably more than the usual time" (Tiwari, 1960). Acoustically a double consonant is a single consonant, with prolonged duration of the crucial part of articulation. They are phonemic as they contrast with single consonant.

bila	'to get lost'
billa	'badge'
əma	'to enter, to get into'
əmma	'mother (in-law)'
bəta	'to tell'
bətta	'rib'

Monosyllabic words are usually stressed in the way described above by the length of the concerned vowel.

Tone

The pitch of voice is not so significant in Bhojpuri as it is in Vietnamese, Chinese, Siamese, or Tibetan and to some extent in Punjabi. Only one or two interjections such as hə̃, (h)ũ: to express ordinary assent undergo change of meaning by change in pitch. But this type of contrast is not seen in any other word.

—hə̃	'yes'	\hə̃	'certainly so'
/hə̃	'is it so'	∿hə̃	'yes, it may be so but ...'

Intonation

Bhojpuri has three meaningful intonation patterns: (1) affirmative or statement, (2) interrogative and (3) exclamatory.

tũ roṭi: khəuwə \	'you ate bread'
tũ roṭi: khəuwə /	'did you eat bread?'
tũ roṭi: khəuwə ∿	'you ate bread!'

The sentence stress dominates over word-stress. Each sentence is divided into bits composed of two or three words. The important words get stressed. The shift of stress from one word to the other within a sentence caused a change of focus resulting in the modification of the meaning of the sentence. Conversely, word which bears stress becomes more prominent than the others, but the basic meaning remains the same.

tũ roṭi: khəuwə \	'it's you who ate the bread!'
tũ roṭi khəuwə /	'is it you who ate the bread?'
tũ roṭi khəuwə \	'you ate the bread (nothing else)'
tũ roṭi khəuwə /	'did you eat (bread) (or something else)'
tũ roṭi khəuwə \	'you did eat (not throw away) the bread'
tũ roṭi khəuwə /	'did you eat bread? (you should not have eaten)'

The types of intonation contours illustrated above would be available in many Indian languages. A detailed study would bring many more details. The suprasegmentals play an important role in the verbal behaviour of the Bhojpuri speakers the glimpses of which are traced above. For an effective communication the strategy of suprasegmentals is employed. It is felt that this area is explored in greater detail.

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INTONATION CONTOURS OF KANNADA

Chandrashekhar Patil

1.1. Introduction

Intonation, the changing melody of speech, is a suprasegmental feature which is closely bound up with attitudes and paraphonological features like gestures. This complexity makes any study of intonation fascinating, but nevertheless, the fact is that no safe conclusion can be arrived at purely on the basis of acoustic experiments. Bread intonation patterns, however, can be recognised especially in relation to the correlating phenomena like pitch and amplitude.

1.2. Present Study

An attempt is made in the following pages to recognise and describe the intonation contours of Kannada, concentrating mainly on statements, questions and surprises.

2.1. The Kannada Language

Kannada is one of the four major Dravidian languages spoken in the southern part of the Indian sub-continent. It is one of the languages specified as the Languages of India in the eighth schedule of the Indian Constitution. Kannada is the Official Language of the Karnataka State.

2.2. Some of the Syntactic and Phonological Features of Kannada

In so far as they are relevant to the present study, are given below:

2.2.1. Syntax

Kannada is an inflected language with a rather unrestricted word-order but displaying a dominant SOV pattern. The intonation contour of an utterance, therefore, is largely unaffected when the information points are switched.

2.2.2. Phonology

(a) Standard Kannada has an inventory of 44 phonemes: 5 short vowels, 5 long vowels, 2 vowel glides and 32 consonants. It has conjunct consonants or consonant clusters. Length, or quantity is a distinguishing feature of vowels.

(b) Kannada is a syllable-timed language, i.e., syllables in utterances receive their full value. But in normal speech, however, many changes such as elision or shortening of vowels, take place.

(c) Like English, Kannada also has 'intonation' contours. But it is not a tone language which uses the variation in the fundamental pitch for expounding lexical and morphological opposition.

(d) Accent, in the sense it is used while describing English, is not employed but there is a strong tendency for it to occur with long vowels and consonant clusters. Word emphasis, on the other hand, occurs in Kannada as a phonetic feature. To make a particular word the main message carrying unit, a Kannada speaker makes use of prosodic features like higher pitch, extra length, pause, loudness, retention of final vowels, etc.

3.1. The Procedure

The author, a native speaker of the Dharwad dialect of Kannada (spoken mainly in the northern part of Karnataka) recorded nine short utterances in the recording studio of the CIIL and later spectrograms of four of these utterances were taken.

3.2. Scalar Notation for Intonation Contours

(a) The Parallel lines represent the medium voice range with three pitch levels - high, mid and low.

(b) The syllables are represented by horizontal lines of varying length - length roughly indicating the quantity of a syllable - and these lines are joined by 'dots' to indicate the 'movement' of the intonation contour.

3.3. The Data

(a) The following utterances were used as data for recording:

(S-1)	ba:ḷ aiti	'is it too much?'
(S-2)	adu be:ku	'I want that'
(S-3)	maja: alla	'it is interesting, isn't it!'
(S-4)	ya:v ka:ka:	'which uncle?'
(S-5)	he:ṇt illa	'wife is not there, one does not have wife'
(S-6)	gra:mar tra:su	'Grammar is difficult to learn'
(S-7)	gondl ya:ka	'why should there be, any confusion at all?'
(S-8)	avanu: satna	'he too died!'
(S-9)	ayyo: pa:pa	'Alas, unfortunate!'

(Spectrograms of only first four sentences were taken)

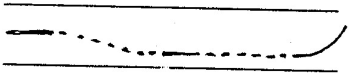
(b) The function-wise grouping of these utterances is as follows:

(i) Statements : S-2, 5 and 6.
(ii) Questions : S-1, 4 and 7.
(iii) Surprises : S-3, 8 and 9.

4. Intonation Contours

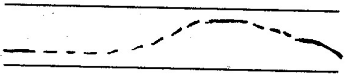
After a careful analysis of the utterances, perceptually, the recorded material and graphically, the spectrograms - the intonation contours are represented by scalar notation.

(S-1) : A statement-turned question of the polar type, expressing sympathy and expecting tacit agreement:



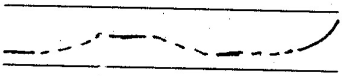
ba:ḷ ai ti 'is it too much'
much is

(S-2) : A plain statement implying request:



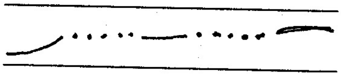
a du be: ku 'I want that'
that wanted

(S-3) : A tag question, sharing an emotion and expecting a tacit response:



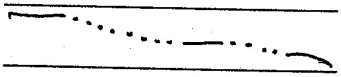
ma ja: al la 'it is interesting,
interesting not isn't it? interesting
not'

(S-4) : A non-polar question, requiring specific information and expressing deep concern:



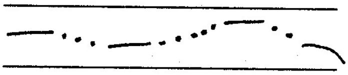
ya:v ka: ka: 'which uncle?'
which uncle

(S-5) : A plain statement:



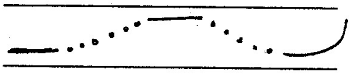
he:ṇ til la 'wife is not there, one
wife not does not have wife'

(S-6) : A plain statement, expressing a sense of frustration:



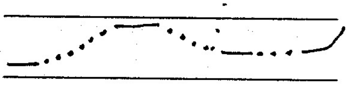
gra: mar tra: su 'grammar is difficult
grammar difficult to learn'

(S-7) : A non-polar question, making a casual remark and not expecting any information:



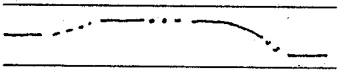
gond lya: ka 'why should there be
confusion why any confusion at all?'

(S-8) : A statement-turned-question of the polar type, expressing sudden shock and surprise and not, expecting any response:



av nu: sat na 'he too died, did he?'
he too died ?

(S-9) : An interjection, expressing a deep sense of sympathy:



ay yo: pa:: pa 'Alas! what an unfortu-
Alas unfortunate nate thing'

5.1. Observations

Intonation contours are identified and described within the framework of three parameters:

(a) Pitch modulation (frequency) - As the modulation in pitch of the Fo is not possible to read, the 10th harmonic in the narrow band spectrogram is traced and the Fo is determined by dividing the frequency readings of the 10th harmonic by 10. This was done for the available spectrograms to verify the perceptual analysis.

(b) Duration (time), recorded along the horizontal axis of spectrograms was measured.

(c) Loudness (intensity) - recorded by the amplitude curve taken on the upper portion of spectrograms was also measured.

5.2. General Observations

Independent of the syntactic status (i.e., Statements, Questions, Surprises, etc.) and the word-orders of the utterances, the following general observations are made:

(a) Words which the speaker thinks are semantically important have a relatively high pitch and they also tend to record pitch-movement: e.g., ba:ḷ (S-1), be:ku (S-2), tra:su (S-6).

(b) Duration also characterises the relative importance of words: e.g., pa::pa (S-1). Also notice extra-length of the final vowels in (S-1) and (S-4).

(c) Intensity also adds to the relative importance of such words: e.g., ba:ḷ (S-1), be:ku (S-2), maja: (S-3), ka:ka: (S-4). The underlined syllables have the highest amplitude peaks on the spectrograms.

(d) Though the end product, as listeners perceive it, is the accumulation of all the above three parameters, these parameters individually do not have a significant communicative property. In other words, all the three parameters are combined in a definite proportion, in order to convey the intended sense. This aspect needs further exploration.

5.3. Statements

(a) The falling intonation is an overall feature of the statements: e.g., (S-2), (S-5) and (S-6).

(b) Within the utterance, however, there are pitch variations, apart from the relevant areas of intonation. These are partly dependent upon the phonetic structure of the componant words of sentence.

5.4. Questions

(a) Polar questions have a rising pitch level at the end. This rise is the only distinctive feature especially in statement-turned-questions which do not have any syntactical cue such as question word: e.g., (S-1).

(b) Non-polar questions, when not emphasised, have a falling pitch level at the end; but, coupled with an attitudinal implication, it may end with a rise: e.g., (S-7).

(c) The question-word in non-polar questions, apart from having a high pitch, also displays pitch movement: e.g., ya:v in (S-4). But in (S-7) the question-word ya:ka is neutralised.

5.5. Surprises

(a) Since surprise is an attitude, an utterance of any syntactical status can be turned into a surprise utterance: e.g., (S-3) is a tag-question, (S-8) is a polar question. (S-9) is a regular exclamatory utterance.

(b) There is a general rise in the pitch-level of these utterance. But the pitch movement at the end may vary, depending perhaps on the syntactic 'form' of the utterance: e.g., rise in (S-3) and (S-8); fall in (S-9).

6.1. Conclusion

The intonation contours of selected Kannada utterances analysed and presented in this paper need to be further looked into against the backdrop of diversified syntactical patterns and semantic as well as attitudinal implications. The general observations made here, based as they are on a very limited data, are far from being conclusive, but they do characterise the intonation contours of certain types of sentences in Kannada.

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INTONATION PATTERNS IN TAMIL

S. Natanasabapathy

Introduction

Tamil is one of the oldest languages of the Dravidian family with the longest continuous written history. Tamil is an Official Language of Tamil Nadu State, and is spoken by a considerable population in Sri Lanka, Malaysia, Singapore, Mauritius, Fiji, Burma, South Africa, Caribbean States and Great Britain. R.E. Asher (1982) puts the figure of Tamil speaking population somewhere around fifty million.

The study of Tamil intonation has not been undertaken so far. In this context, R.E. Asher (1982) said that Tamil intonation, like the stress patterns of the language, has been a neglected area. So it is attempted in the present paper to probe into some of the areas in intonation patterns in Tamil so that an elaborate research work could be taken up later. In other words, this paper aims at a pilot study of some of the prominent intonation patterns and mark the corresponding pitch levels. One of the aims is also to know the strategies that are a adopted in different intonation patterns of the speakers.

Experimental Procedure

As this work is done on an experimental basis to probe into the intonational mechanism of Tamil, the study was undertaken with one subject only. For the purpose of the present investigation, simple sentences with one, two and three words were selected. The selected material with various intonations was presented to ten Tamil speakers for identification test. After the test, the material was recorded by the informant in the recording studio. Each sentence was recorded three times and maximum care was taken to ensure the natural performance. Then the data was fed to the spectrograph model-6061B (Kay Elemetrics) to get the narrow band spectrograms with amplitude display.

The sentences were recorded with neutral intonation (statement), interrogative intonation, emphatic intonation and contrastive stress. The following is the list of sentences considered for this study.

A. Neutral Intonation (Statement)

1) ra:ta	'Radha (name of a girl)'
2) po:na:n	'he went'
3) avan po:na:n	'he went'
4) poṇṇa: atu	'is it a girl?'
5) nalla ve:ḷe	'auspicious time'
6) ṅalla: irukku ñ̃a:yam	'justice is good'
7) ma:tavi nalla poṇṇu	'Madhavi is a good girl'
8) na:n maturekki po:re:ṅ	'I'm going to Madurai'

B. Interrogative Intonation

1a. ra:ta:?	'is it Radha?'

This contains an element of surprise and is not normally uttered as an initial attempt to seek a piece of information but rather to check on the truth of something said.

1b. ra:ta:va:?	'is it Radha?'
2a. po:na:n?	'did he go?'

(Expression to confirm something said earlier or expression of surprise)

3a. avan po:na:na:?	'did he go?'
3b. avana:po:na:n?'	'is it he who went'

C. Emphatic Intonation

4a. poṇṇa: + adu	'she is not a girl at all'
5a. nalla + ve:ḷe	'fortunately/luckily!'
6a. nalla: irukku + ña:yam	'the justice is not good!' (Ironical sense-negative)

D. Contrastive Stress

7a. mo:tavi nalla\poṇṇu	'Madhavi is a good girl' (with certainty)
7b. ma:tavi\nalla poṇṇu	'Madhavi is a good girl but ...' (non-terminal clause)
8a. na:n maturèkki po:re:n	'I am going to Madurai only' (and no where else)
8b. na:n maturekki pò:re:n	'I am going to Madurai and not returning'

Graphs were drawn for all the sentences in frequency Vs. time scale, after noting down all the Fo (fundamental frequency) and duration of the syllables.

Observation

There are three major types of intonation patterns observed from the above data with reference to pitch movement in the last syllable, or, in most cases where the vowel in this syllable is short, in the penultimate syllable. The three main types of movements are -

(i) fall to a low pitch "↘"

(ii) rise to a relatively high pitch "↗"

(iii) rise-fall ending on a medium to low pitch "/↘"

Discussion

A) Statements

These are characterised by a falling intonation on the final syllable or in the penultimate syllable, in case of final short syllable. The fall appears to be gradual in all the sentences with one, two or three words.

B) Interrogatives

According to R.E. Asher, there are two types of interrogative sentences: Yes-No questions, with tag questions as a subset of these; and question-word question. In neither question is the interrogative element related to the word-order. Without the addition of -aa, a declarative sentence can function as a Yes-No question if uttered with a slightly rising rather than with a falling intonation. If the interrogative particle -aa is suffixed to the last word in Yes-No questions, the final syllable has a rise-fall on this particle. If for the purpose of focus, the interrogative particle is elsewhere other than in sentence final position, there is rise-fall on this particle and a fall at the end of the sentence. This fact can clearly be seen by comparing the intonation patterns of 3a and 3b. E-questions, as called by R.E. Asher (1982), alternative questions and other types of questions were not considered in this study.

C) Emphatic Intonation

T. Balasubramanian (1981 : 150) discusses three ways of emphasis in Tamil. They are -

(i) to prolong a vowel that is phonologically long, to prolong a consonant or to introduce a glottal onset to the initial vowel,

(ii) there is a corresponding intonation effect and

(iii) the addition of one of the two emphatic particles [e:] and [ta:n].

He did not discuss anything about the last two ways in his article. The electrokymograph alone was used for his study. So, it is attempted here to give an intonation pattern for the emphatic intonation. Syllables in non-emphatic speech are relatively evenly stressed. However, distinctly stronger stress can be placed on a word for the purpose of contrastive emphasis.

On a closer examination of all the three sentences under C and their intonation patterns, it can be noted that either the penultimate or final syllable gets the stress which is reflected by the highest pitch which it gets. The durational difference which one gets for the sentence between the neutral intonation and emphatic intonation is distributed among the syllables in the emphatic sentences, including the nasals and laterals.

From the auditory point of view, it appears as though the stress is on the first word and also there appears to be a pause between the words. But in the spectrogram, there is no cue suggestive of a pause and also the stress is on the final word. The perception of a pause between the words may be due to the distribution of extra-duration of all the syllables in the word.

D) Contrastive Stress

The effect of contrastive stress on the Fo peak is similar to that of emphatic stress, there being a higher than average peak on the element average peak on the element contrasated with some other.

A careful scrutiny of the sentences under D and the analysis of their intonation patterns were done. It could be definitely said that when the stress is placed on any syllable of a word in a sentence, the Fo rises to the maximum on that syllable, as also the durational difference obtained between the neutral intonation and contrastive stress intonation is distributed over all the syllables of the stressed word.

Inferences Made From This Study

1) Generally Fo increase corresponds with the durational difference which is distributed among all the syllables in a word.

2) Pitch and duration seem to play an important role in Tamil intonational mechanism.

3) On the basis of auditory perception, what are perceived as pause/juncture and loudness are proved otherwise there is no pause between words and what one perceived as loudness is always accompanied with higher pitch. Loudness is not practically independent of pitch, though theoretically it is.

4) When the stress is placed on a syllable, the articulating organs have to readjust and in this process, the durational difference would crop up.

Conclusion

This model is a over-simplified version of the facts as they were found in this limited data and it must be regarded as provisional. The tonal characteristics of stress group and its dependence on clause or word boundaries have not been studied in this piece of work. Study of these intonation patterns needs to be undertaken in depth.

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FEATURES OF DOGRI TONES

Updesh Kaur

Dogri is a tone language. Three tones in Dogri are contrasting.

1) Level tone [-]
2) Low tone [\`]
3) High tone [´]

These tonal features distinguish dogri from the other Indo-Aryan languages such as Hindi, Bengali, etc., whereas they bring Dogri closer to Punjabi.

Some observations about Dogri tones have been made by Ujjal Singh Bahari, Gaurishanker and Dr. Veena Gupta. Dr. Ved Ghai has done some instrumental analysis of Dogri tones, but it is not a detailed study.

The work on the tonal system of Punjabi language has been done by T. Graham Bailey, H.S. Gill, H.A. Gleason, Kalicharan Bahl, Harkirat Singh and others. However, the instrumental analysis in detail has been strongly advocated by Balbir Singh Sandhu in his book The Tonal System of Punjabi. In this book he has also taken up the diacronic aspects of the tones and has shown that these tones have developed in Punjabi language due to the loss of voiced aspirates. To illustrate this, he cites the following examples. It may also be seen that the tones in Dogri also developed in the same historical process.

Sanskrit	Hindi	Punjabi	Dogri	
ghōṭaka	ghōṛa	kòṛa	kòṛa	'horse'
dharma	dharəm	tɛ̀rm	tɛ̀rm	'caste'

This historical change can be stated as under:

$$\begin{array}{ccccc} \underline{\text{Sanskrit}} & & \underline{\text{Hindi}} & & \underline{\text{Punjabi-Dogri}} \\ \left.\begin{matrix}\text{bh}\\ \text{dh}\\ \text{\d{d}h}\\ \text{jh}\\ \text{gh}\end{matrix}\right]\text{V} & \longrightarrow & \left.\begin{matrix}\text{bh}\\ \text{dh}\\ \text{\d{d}h}\\ \text{jh}\\ \text{gh}\end{matrix}\right]\text{V} & \longrightarrow & \left.\begin{matrix}\text{p}\\ \text{t}\\ \text{\d{t}}\\ \text{c}\\ \text{k}\end{matrix}\right]\grave{\text{V}} \end{array}$$

The low tone has replaced the voiced aspirated series in the initial position by the respective voiceless unaspirated ones.

When voiced aspirated series or /h/ occur in the final position in Sanskrit in the corresponding words in Dogri these have been replaced by the high tone. This change may be depicted as under:

$$\begin{array}{ccccc} \underline{\text{Sanskrit}} & & \underline{\text{Hindi}} & & \underline{\text{Dogri}} \\ \text{CV}\left[\begin{matrix}\text{bh}\\ \text{dh}\\ \text{\d{d}h}\\ \text{jh}\\ \text{gh}\end{matrix}\right. & \longrightarrow & \text{CV}\left[\begin{matrix}\text{bh}\\ \text{dh}\\ \text{\d{d}h}\\ \text{jh}\\ \text{gh}\end{matrix}\right. & \longrightarrow & \text{C}\acute{\text{V}}\left[\begin{matrix}\text{b}\\ \text{d}\\ \text{\d{d}}\\ \text{j}\\ \text{g}\end{matrix}\right. \end{array}$$

Examples:

Initial Position

	Hindi	Punjabi-Dogri	Gloss
/bh/	bhəlāi	pə̀lāi	'safety'
/gh/	ghərāna	kə̀rāna	'family'

	Hindi	Punjabi-Dogri	Gloss
/dh/	dhərəm	tə̀rəm	'caste'
/ḍh/	ḍhol	ṭòl	'drum'
/jh/	jhə̃ḍa	cə̃̀ḍa	'flag'

Medial Position

/bh/	lābh	láb	'advantage'
/jh/	səməjh	səmə́j	'understanding'
/ḍh/	ḍhũḍh	ṭṹḍ	'search'
/gh/	sũgh	sṹg	'smell'

Final Position

The occurrence of /bh, gh, ḍh, dh, jh/ is replaced by high tone with /b, g, ḍ, d, j/ in the medial and final positions by the respective voiced unaspirated ones.

/bh/	ləbhəna	ləbə́na	'to get, find'
/gh/	sũghəna	sũgə́na	'to smell'
/dh/	sudhar	sudár	'to reform'
/ḍh/	ḍhũḍhəna	ṭũḍə́na	'to search'
/jh/	səməjhana	səməjána	'to understand'

The aim of this paper is to explore the tonal feature of Dogri with modern instruments, so that these may be understood properly.

Recording Procedure and Method

A very restricted data was prepared. The data contained the contrasting pairs of words for tone. It was recorded in the Phonetics Laboratory of CIIL.

pī	'drink'	kōṛa	'whip'
pì	'again'	kòṛa	'horse'
pí	'grind'	kóṛa	'lepper'
pā	'put'	kāni	'blind'

pà	'cost'	kàni	'story'
bà	'air'	thōṛa	'less'
bá	'surprise or unhappiness'	thòṛa	'hammer'
	(interjection)	ūnda	'their'
ə̄ṭh	'eight'	ùnda	'happen, verb'
ə̀ṭh	'bald'	mōr	'peacock'
rò	'stay'	mór	'stamp'
ró	'temper or anger'		

The recorded material was fed to the spectrograph 6061B of Kay Elemetrics and the narrow band spectrograms were taken. The tenth harmonic of the narrow band spectrograms were traced out to mark the modulation of the tones.

Level Tone:

In the case of level tone in monosyllabic (CV, CVC) words the contour of the fundamental tone, calculated on the basis of the 10th harmonic by dividing it by ten, moves from the main register line and remains on the level and sometimes rises gradually. Therise in Fo at the end or middle is only by about 20 Hz which occurs after 70 m/secs., but before 150 m/secs.

In the case of disyllabic words (CVCV) the contour of the fundamental tone on the first vowel remains at level, but that of the second syllable rises slightly due to the impact of intonation. It may show a slight fall or rise which is not significant in the case of this tone. The contour of this tone remains more or less at one level. In disyllabic words the rise in Fo is by 20 Hz to 40 Hz, which occurs between 200 m/secs. and 220 m/secs.

Low Tone:

In the case of low tone the contour of fundamental frequency (Fo) in mono-syllabic words falls from high level to low level. The fall ranges from 30 Hz to 70 Hz in 120 m/secs. In disyllabic words the contour of fundamental frequency (Fo) falls and then remains on the level sometimes, it rises gradually in the first syllable and then falls in the second syllable. The fall of the contour of Fo in the first syllable ranges from 50 Hz to 110 Hz which occurs between 70 m/scs. to 150 m/secs. and then it will remain level. In the second syllable, the contour may rise and then fall. But the rise and fall of contour on the second syllable do not create any problem for the realization of the low tone.

In the end, it may show rise or fall, as has been investigated by some scholars. It is the first fall, which gives the cue for the low tone in Punjabi. Thus the fall in the first syllable plays a significant role in the preception of low tone.

High Tone:

In the case of high tone in monosyllabic words the contour of fundamental frequency (Fo) rises from the main register line. This rise may range from 40 Hz in the first 70-80 m/secs. In the end, it may show rise or fall depending upon the intonation contour.

In disyllabic words, the contour of the fundamental Frequency (Fo) rises first, and then falls. It rises up to 190 m/secs. and then falls on the second syllable. This means that it shows rising-falling picture. So that the high tone marked by rising or rising-falling contour.

Conclusion

The above features establish that there are three tones in Dogri. They correlate with Punjabi tones. The duration and the fundamental frequencies of Dogri tones are given in the Table below:

Table 1 : Duration and Fundamental Frequency (Fo) of Dogri Tones

		Tone		
		Level [-]	Low [ˎ]	High [ˏ]
Monosyllabic Words				
Minimum :	Duration in m/secs.	120	120	230
	Fo Hz	160	227	250
Maximum :	Duration in m/secs.	300	320	400
	Fo Hz	268	283	285
Average :	Duration in m/secs.	260	260	312.25
	Fo Hz	250	257	249
Disyllabic Words				
Minimum :	Duration in m/secs.	390	400	245
	Fo Hz	250	227	247
Maximum :	Duration in m/secs.	410	420	250
	Fo Hz	310	297	250
Average :	Duration in m/secs.	398	407.5	247.5
	Fo Hz	278	254.25	248.5

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A NOTE ON MANIPURI TONES

Laishram Mahabir Singh

Manipuri, a Tibeto-Burman language, has been analysed (Mahabir, 1982) as having two lexically contrastive tones: level /-/ and fall /\/. These tonal oppositions are exemplified in the following words: /pī/ 'tears' and /pì/ 'to give'. Average fundamental frequency contours of the two-tones in isolation are presented in Fig.1.

Here, I am investigating the relative importance of fundamental frequency, as well as amplitude and duration as perceptual cues in distinguishing the fall tone from the level tone, though they (amplitude and duration) are not significant in the language. In order to provide the information lacking in the earlier studies, I did the following experiment. I used myself as the subject of the experiment. I pronounced eight V, VC. CV and CVC monosyllabic morphemes. The recording was done in a studio room. The measurements were taken on a pitch analyzer (at the All India Institute of Speech and Hearing, Mysore). My acoustic analysis indicates that the fall tone displays a higher initial level of fundamental frequency, a falling fundamental frequency contour (18 Hz), a shorter duration (146 m/secs.), and a lower amplitude (4dB). I present the data in Table 1. Examples:

/ī/	'to write'	/ì/	'blood'
/pī/	'tears'	/pì/	'to give'
/ōy/	'to be'	/òy/	'left'
/thōṅ/	'bridge'	/thòṅ/	'door'

Observations

1) For level tone, the contour rises by about 20 Hz in the first 150 m/secs. and falls by about 10 Hz in the next 200 m/secs.

2) For fall tone the contour rises by about 5 Hz in the first 100 m/secs. and falls by about 35 Hz in the next 150 m/secs.

Table 1 : Data of the Analysis

	Morphemes (monosyllables)							
	/ī/	/ì/	/pī/	/pì/	/ōy/	/òy/	/thōṅ/	/thòṅ/
Initial								
Freq. (Hz)	250	259	243	259	243	226	232	234
Ampl. (dB)	56	46	77	75	77	74	70	69
Highest								
Freq. (Hz)	275	265	282	290	480	401	245	241
Ampl. (dB)	60	46	78	77	146	88	78	76
Final								
Freq. (Hz)	265	230	243	194	480	270	241	223
Ampl. (dB)	56	46	56	71	46	46	68	65
Ave. Freq. (Hz)	264	246	298	277	300	275	241	234
Duration in m/secs.	360	242	330	221	460	270	320	150

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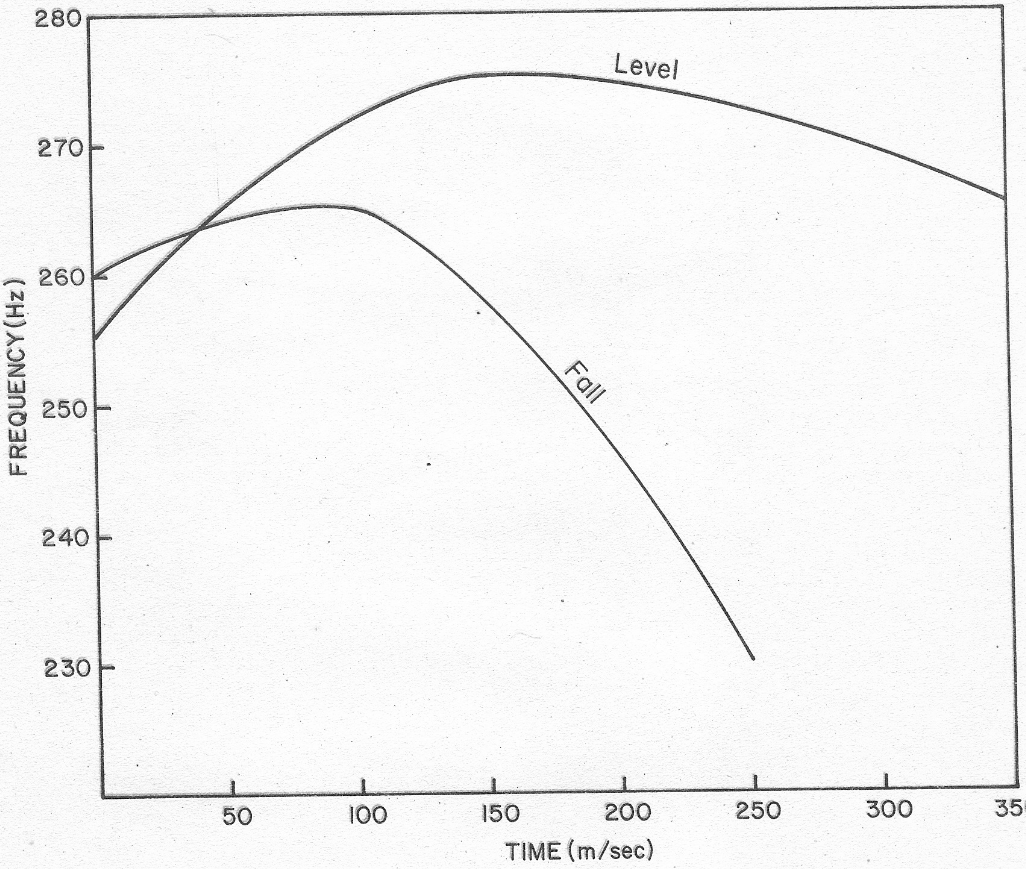

Average Fundamental Frequency Contours
of Manipuri Tones in Isolation

A NOTE ON THE TONES OF MOYON

Donald Kosha

Moyon is a Tibeto-Burman language, spoken by a Naga sub-group of people called Moyons, who are settled in the South-Eastern region of Manipur and Burma, along the borders of Manipur. It exhibits similarities with some of the Naga languages of Nagaland, such as Angami, Ao, etc., and definitely with other Naga languages of Manipur, such as, Mao, Tangkhul and others, and also with the Kuki-Chin group of languages. These phenomena will be interesting topics for further research.

Like the other neighbouring Tibeto-Burman languages, Moyon is also a tonal language. A word can have different meanings with different tones, which are three in number, e.g., the word [tʃ a] with high rising tone [tʃ á] means 'cry after (imperative)' with low tone [tʃ à] means 'be good (advisive)' and with high level tone [tʃ ā] means 'mourn (imperative)'. A word can also have more than three meanings, in which case, after the three tones, the rest will be understood from context, for instance, the word [ra] can mean axe, sickness, pour, flower and demarcation. In this case, for the word 'axe', there will be low tone [rə̀], high tone for 'sickness' [rə́] and high level tone for 'demarcation' [rə̄], and the rest will be understood from their context. Similarly a change of tone or stress in a word, can give different shades of meaning with different degrees of feeling, for example, [i̱nu̱ṅæ̱ve̱] (low level tone) means 'it was sufficiently enjoyable', (inuṅævé) (high tone on the last syllable) means 'it was very enjoyable, [inuṅævè] (low level on the last syllable) means 'it was extremely enjoyable, and (ìnùṅæ̀vè) (the tone of each syllable lower than the previous one) means 'it was so enjoyable that, no other thing can be more enjoyable than that'. In this way, many similar examples can be cited.

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